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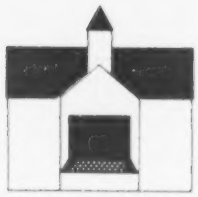
Instructional Uses of School Computers



Reports from the 1985 National Survey Issue No. 1, June 1986

Center for Social Organization of Schools The Johns Hopkins University

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Schools are not known for being quick to change. Over a two year span, you would not expect to find many changes in school instructional practices. But, think about how schools have invested in computers over the past few years.

Between Spring 1983 and Spring 1985, in U.S. elementary and secondary schools, the following changes occurred:

* The number of computers in use quadrupled from about 250,000 to over one million.
* Three-quarters of the schools which had not previously used computers began to do so.
* The proportion of elementary schools with five or more computers jumped from 7% to 54%.
* The proportion of secondary schools with 15 or more computers rose from about 10% to 56%.
* The typical computer-using secondary school went from five computers in use to 21 in high schools and to 14 in middle schools.
* The typical computer-using elementary school went from two computers in use to six.
* During the 1984-1985 school year, approximately 15 million students and 500,000 teachers used computers as part of their schools' instructional programs.

These summary statistics are calculated from data collected in the Second National Survey of Instructional Uses of School Computers, the most extensive survey on school computer use to date. The survey gathered information from more than 10,000 teachers and principals in a probability sample of over 2,300 U.S. elementary and secondary schools during the Spring of 1985. This report -- the first of six to be issued from this survey -- concentrates on basic numbers. In a typical school, how many students and how many teachers use computers? How much are the computers actually used? For what instruction are they used? Where are the schools' computers located? How much time do individual students get to use school computers?

Are Schools Now Well-Supplied With Computers?

By the Spring of 1985, almost all secondary schools and five-sixths of the elementary schools in the U.S. had begun to use computers in their instructional program (Table 1). Ninety percent of U.S. school children attended schools that had at least one computer.

GENERAL NOTES ABOUT TABLES AND FIGURES

General descriptive data is usually tabulated according to the grade span of the school, with each school in the sample assigned to the best-fitting grade span category. Six categories were used: K-6, Middle, High School, K-8, K-12, and Junior-Senior Highs. Comparisons with 1983 survey data are limited by the less detailed categories used in the analysis of the earlier survey ("elementary" included K-6 and K-8; "secondary" included all others except K-12 schools which were omitted from the 1983 analyses.) The text discusses most data presented in tabular form. However, some table data is presented without comment, and some information discussed in the text is not included in the tables.

Table 1: Percent of U.S. Schools Using Any Computers for Instruction, Using 5 or More, and 15 or More Computers by Grade Span of School, Spring, 1985.

Grade Span of School	Percent of U.S. Schools		
	Any Computers Used For Instruction	5 or More Computers	15 or More Computers
K-6 Elem.	85%	57%	12%
Middle/Jr.High	95%	85%	47%
High School	97%	92%	68%
K-8 Elem.	81%	46%	9%
K-12 School	72%	48%	11%
Jr./Sr. High	90%	82%	45%
U.S. Total	86%	63%	24%

But schools were not obtaining computers one or two at a time. They were obtaining them in fours, sixes, and fifteens. Schools had learned that they needed large numbers of computers if computers were to be more than showpieces for outside visitors. Schools, after all, are organized to provide instruction to students in groups of 20 or 30 or 40. To be functional, school resources must match the setting in which they offer instruction.

By last Spring, large investments in computer hardware over the preceding two years had brought the typical school to a ratio of one computer for roughly every 40 students (Table 2). Yet even a 40-1 ratio cannot provide most students at a school with a substantial amount of computer time.

How much computer time students should have is, of course, a complex issue. The effectiveness of computer-based instruction depends not only on software quality and hardware sophistication, but on (1) how well computer activities are integrated into other instructional activities, (2) whether there are alternative and less expensive ways that students can achieve comparable academic competencies and understanding, and (3) whether it is more important that students learn those particular things rather than other skills or competencies that might not be best learned using computers. The optimum allocation of computer time is likely to increase over time, and may vary for children of different ages, prior backgrounds, abilities, or preferred learning styles.

Table 2: Median Number of Computers and Median Student-Computer Ratio in U.S. Schools with Computers by Grade Span of School, Spring, 1985.

Grade Span of School	Median Number of Computers	Median Ratio of Students to Computers
K-6 Elem.	6	60-1
Middle/Jr.High	14	41-1
High School	21	31-1
K-8 Elem.	5	41-1
K-12 School	6	26-1
Jr./Sr. High	14	25-1
U.S. Total	8	42-1

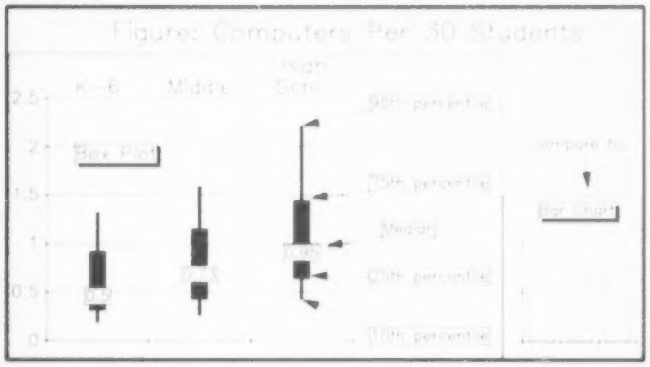
However, even today, under the right conditions, a typical high school student could profitably use computers for writing compositions, for memorizing whatever facts are truly unavoidable, for understanding relationships and concepts in mathematics and science courses, and for writing computer programs. Each of these SEPARATE uses might occupy 30 minutes to 3 hours of computer time per week. Thus, a high school student might profitably use computers for an hour or two per DAY.

Despite their increasing acquisition of computers for instruction, hardly a school in the country has the computer resources to give that much computer time to each of its students. To provide even 30 MINUTES of computer time per day to all students enrolled, a school would need to have one computer for every 12 students -- and that assumes the computers are in constant use for 6 hours per day, with no time lost to transitions, scheduling foul-ups, or other interruptions. As of Spring, 1985, such a favorable student-to-computer ratio was available at only 7% of high schools and roughly 2% of elementary and 3% of middle schools in the country. Yet, by limiting the number of students who use school computers, many schools do provide a substantial experience to at least some of their students.

How many students use school computers?

During the 1984-1985 school year, nearly half of elementary and middle school pupils and as many as one-third of U.S. high school students made some use of computers at school.

During an average week, at a typical computer-using school, more than one-quarter of the student body used computers. Students in elementary schools were more likely to have some use of computers than were students in secondary schools. For example, at a typical K-6 computer-using school, 30% of the students used computers during an average week, while at a typical high school only 21% used computers. The typical computer-using



THE "BOX PLOT"

Figures such as the one above are included at several points in this issue to provide information both about the "typical" school and the range of variation that exists on some aspect of the presence of computers in the schools, such as (in the above example) the number of computers at each school per 30 students enrolled.

The box plot has 3 elements. The number enclosed in the transparent square gives the median (number of computers per 30 students enrolled) for the group of schools indicated at the top of that column (e.g., K-6 elementary schools, for the first column). The median would be the only element appearing in a more conventional chart.

The other two elements of the box plot assume that each group of schools is ranked from "lowest" to "highest" on the measure in question (e.g., from schools with the fewest computers per 30 students to those with the greatest number). The solid black rectangle represents the middle 50% of schools (encompassing the 25th to the 75th percentiles), according to their computer-to-student ratio. The line segments extending upward and downward from this rectangle represent most of the remaining schools -- those from the 75th to the 90th percentiles and those from the 10th to the 25th percentiles.

The box plot allows one to draw a number of conclusions not possible with the basic bar chart. For example, schools at the 90th percentile have more than twice as many computers per 30 students as the median school of the same grade span. Schools at the 10th percentile have one-third to one-half as many as the median school. The top 25% of the computer-using K-6 elementary schools have roughly the same computer ratios as half the high schools do. And nearly all schools have fewer than 2 computers per classroom of students (if they were spread among all classrooms).

school provided computer opportunities to about twice as many students in 1984-85 as they did two years earlier. (In 1983, roughly 15% of the typical elementary school's student body and 11% of the typical secondary school's student body had used computers during an average week.)

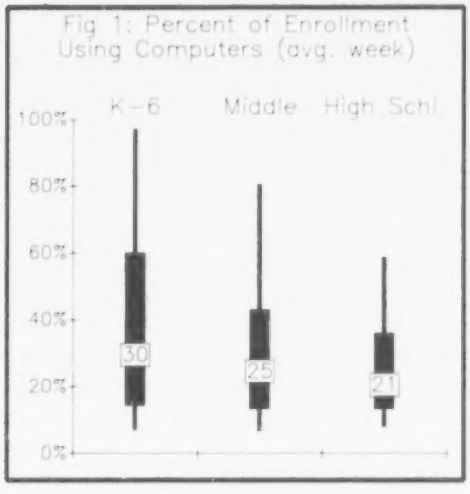
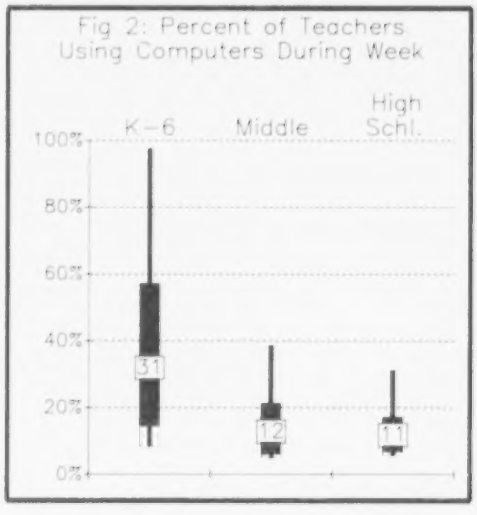


Figure 1 shows that computer-using schools varied widely in how much they spread computer experiences among their students. One-fourth of computer-using K-6 elementary schools reported that a majority of their students used computers during an average week. About 15% of high schools reported use by a majority of their students. At the other extreme, one-fourth of computer-using schools at all levels reported that fewer than one out of seven of their students used computers during an average week. The proportion of students who used computers sometime during the full school year was somewhat higher, but the differences across schools were similar to those shown in Figure 1 for one week's activity.

How many teachers use computers?

One-fourth of all U.S. teachers used computers "regularly" with students during the 1984-85 school year. A much higher proportion of elementary school teachers did so (37% in the K-6 schools) than did secondary school teachers (15%). Similarly, during an average week at the typical computer-using elementary school, 31% of the teachers used computers with students, but during that same week only 12% of the teachers at a typical secondary school used computers with students (Figure 2). However, because schools with older students tend to be larger, roughly the same NUMBER of teachers (5 per school) used computers regularly during the year at the median computer-using school at all three levels — elementary, middle, and high school.



For each school, we obtained an estimate of the number of computer-using teachers who were "expert" in each of four aspects of using computers -- "using some instructional programs," "knowing about a wide variety of programs," "using word-processing or other professional tools," and "writing computer programs." In each area, a much higher proportion of secondary school computer-using teachers were viewed as expert (Figure 3). Overall, combining these four areas of computer-related knowledge, 27% of computer-using high school teachers were viewed as experts as were 21% of computer-using middle school teachers, but only 10% of computer-using elementary (K-6) school teachers.

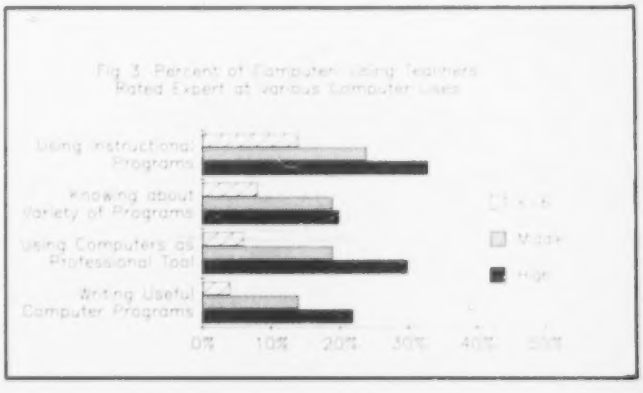


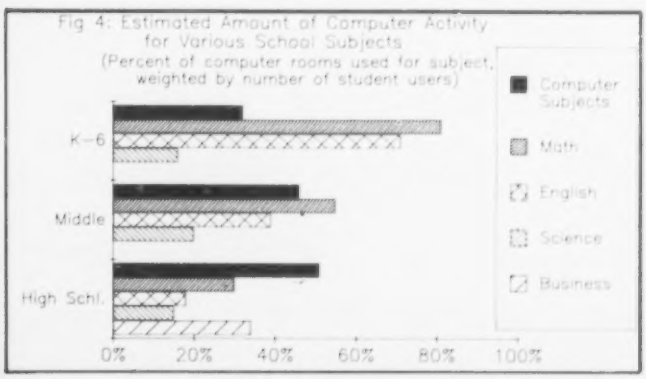
Table 3: Mean Percent of Instructional Computer Time (Global Assessment by PCUT), Spring, 1985.

Grade Span of School	Drill & Practice	Discovery Learning Problem Solving	Programming	Word Processing	Other
K-6 Elem.	56%	17%	12%	9%	6%
Middle/Jr.High	30%	15%	32%	15%	9%
High School	16%	10%	49%	20%	5%
K-8 Elem.	49%	19%	19%	6%	8%
K-12 School	39%	11%	31%	16%	3%
Jr./Sr. High	25%	12%	40%	20%	3%
U.S. Total	32%	14%	33%	15%	6%

What are the major instructional uses of school computers?

The ways students use computers differ sharply by grade level, as one would expect. More than half of the student use of computers in elementary schools involves using "drill-and-practice" and "tutorial" programs (that is, "computer-assisted instruction" or "C.A.I.") and only about 12% of their time is spent writing computer programs. In contrast, high school students spend only 16% of their computer time on computer-assisted instruction, but spend half their time programming (Table 3). Across all school levels, about one-third of student instructional time on school computers is for "C.A.I.," one-third is for programming, and one-third is for all other academic work, including "discovery learning" and word processing.

Mathematics and language arts (English and reading) are the major subjects for which computers are used in elementary schools. These two are joined by computer literacy as a third major use in middle schools. In high school, computer literacy and programming are the dominant subjects, with business education and mathematics following about equally far behind. (Figure 4 gives a rough guide to actual use in different subjects. It is a summary report of computer uses for each room in the school that has computers. Future newsletters will report more detailed data reflecting how each computer-using teacher uses computers for particular classes and subjects.)



How much computer time for a typical student computer-user?

The amount of experience that any one computer-using student had with school computers doubled between 1983 and 1985. In 1983, a typical elementary school student who used a computer during a week had about 20 minutes of computer time. By 1985, the typical elementary school student had 35 minutes of computer time. At the secondary school level, time per student user also doubled, increasing from about 45 minutes per week to roughly 90 minutes per week. The median high school student user had even more time -- an hour-and-three-quarters per week (Figure 5).

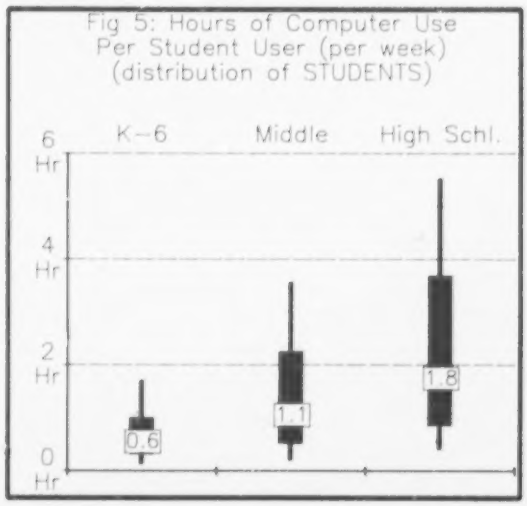
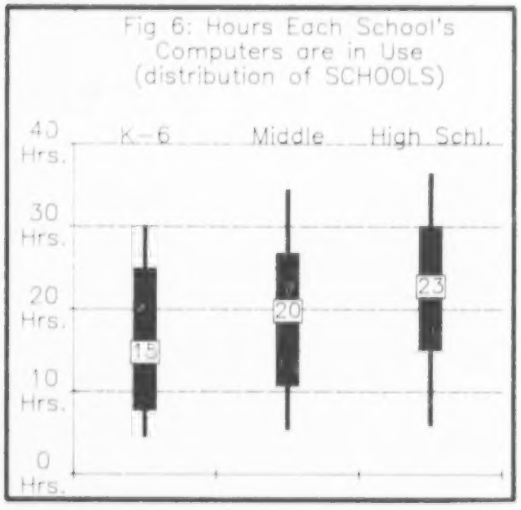


Figure 5 shows a substantial spread among computer-using students in how much computer

time they have during an average week. The 10% of computer-using students with the most computer time use the computer at least three times as much as the typical computer-using student at the same grade level. In fact, although not shown in Figure 5, the most active 10% of computer-using students at each school level --elementary, middle, and high school -- take more than one-third of all student computer time, while the most active 25% get roughly three-fifths of all student computer time.

How much use is each computer getting and which schools are using their computers more?

Students are getting more time to use computers at school for two reasons: there are more computers at each school, and each computer is used more. In 1983, schools used their computers, on average, for about 12 hours per week (11, elementary; 13, secondary). In 1985, the typical computer was used about 50% more, with the increases somewhat greater in secondary schools than in elementary schools. The typical high school used its computers for 23 hours per week (including before and after school use), the typical middle school used its computers for 20 hours per week, and the typical K-6 elementary school used its computers for 15 hours per week (Figure 6).



Schools with more computers use them more. For example, high schools with 15 or more computers use them an average (mean) of 24 hours per week while high schools with 3-5 computers use them for only 17 hours per week. Elementary schools with 15 or more computers use them for 20 hours per week, while those with only 3-5 use them for 16 hours per week.

Are computers grouped together, and does this enable classrooms of students to use them at once?

Schools with a substantial number of computers can cluster them together or scatter them throughout the school. Only if clustered together in groups of eight or 12 or 15, can a substantial fraction of any one teacher's class use computers at the same time. Most schools do keep their computers in one, two, or three locations in their building. The typical elementary and middle school keeps its computers in two rooms, and the typical high school uses three rooms for its computers.

Yet because elementary schools still have a limited number of computers, even with clustering most elementary teachers cannot use computers with all or half of their students at the same time. Only 6% of the K-6 schools have 15 or more computers in one room. In contrast, nearly half of the computer-using high schools have 15 or more computers in one room (Table 4).

Table 4: Percent of Schools with a Substantial Number of Computers in a Given Location by Grade Span of School, Spring, 1985.

Grade Span of School	Percent of Computer Using Schools With:	
	7 or More Computers In Any One Room	15 or More Computers In Any One Room
K-6 Elem.	22%	6%
Middle/Jr.High	67%	35%
High School	85%	47%
K-8 Elem.	26%	4%
K-12 School	24%	4%
Jr./Sr. High	64%	26%
U.S. Total	39%	16%

In addition, even when elementary schools have the same number of computers as secondary schools, they tend to place their computers in more locations. For example, elementary schools with 10 to 14 computers divide their computers among 50% more locations than do middle or high schools with the same number of computers (a mean of 4.0 locations per school vs. 2.7 for secondary schools). Elementary schools that keep their computers in one or two locations use them roughly 10% more than do those that spread them among more locations.

Table 5: Computers in Classrooms by Grade Span of School, Spring, 1985.

Grade Span of School	Percent of Schools* With Any Computers in Classrooms	Percent of All Instructional Computers that Are in Classrooms	Percent of Schools* With Computers in More than 3 Classrooms	Percent of Computer Classrooms With more than 3 Computers
K-6 Elem.	76%	40%	22%	10%
Middle/Jr.High	70%	27%	9%	27%
High School	82%	38%	12%	44%
K-8 Elem.	67%	38%	10%	13%
K-12 School	81%	47%	13%	20%
Jr./Sr. High	81%	37%	7%	39%
U.S. Total	75%	37%	15%	20%

*Schools using computers for instruction.

Where are computers housed in school buildings, and are computers used differently in different types of rooms?

Computers used for school instruction can be found in classrooms, laboratories, libraries, offices, and hallways. They can be fixed or on mobile carts, rotating among several rooms. Here we summarize data on the number of computers by the type of room in which each computer mainly resides. Data for classroom computers are in Table 5; data for computers in labs and libraries are in Table 6.

Most computer-using schools (75%) have at least one computer in one classroom. Only about 44% of computer-using schools have a computer laboratory. Yet more school computers are in laboratories (49%) than in classrooms (37%). That is because a classroom typically has only one to three computers, and usually only one or two classrooms in a building have computers. In contrast, the typical secondary school computer lab has 13 or 14 computers and the typical elementary school lab has 8 computers. Most schools that have computer labs have only one, but almost 25% of computer-using high schools have more than one laboratory.

A much smaller proportion of K-6 elementary schools have laboratories (30%) than do middle (62%) or high (69%) schools. Yet the proportion of elementary school computers that are in classrooms

Table 6: Computers in Computer Labs and Libraries by Grade Span of School, Spring, 1985.

Grade Span of School	Percent of Schools* With Any Computers in:		Percent of All Instructional Computers in:		Median Number of Computers in a:	
	Lab	Library	Lab	Library	Lab	Library**
K-6 Elem.	30%	31%	40%	13%	8	2
Middle/Jr.High	62%	32%	62%	6%	14	2
High School	69%	33%	51%	4%	13	2
K-8 Elem.	43%	17%	46%	9%	7	4
K-12 School	46%	14%	44%	3%	7	1
Jr./Sr. High	52%	32%	53%	5%	11	2
U.S. Total	44%	28%	49%	8%	10	2

*Schools using computers for instruction.

**Among libraries with at least one computer.

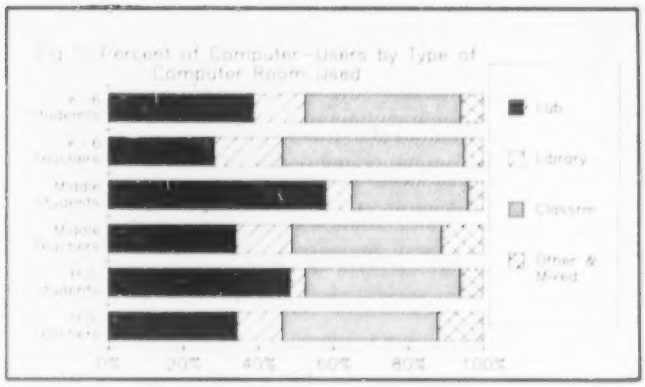
is roughly the same as the proportion of high school computers in classrooms (40% vs. 38%). Mainly this is because each elementary school classroom has so few computers. Of the elementary school classrooms with computers, 90% have three or fewer. In contrast, nearly half of the high school classrooms with computers have more than three. Also, libraries in elementary schools may act as "mini-labs." A higher proportion of elementary school computers are in libraries (13% in K-6 schools vs. 4% in high schools), although the typical elementary school library that has computers has only two of them.

Of all school levels, middle schools have the largest proportion of their computers located in laboratories. More than three-fifths of their computers are in labs, and their labs are just as large as those in high schools. Their greater clustering of computers extends to libraries as well. When middle schools put computers in libraries, typically they place four computers in them, twice as many as at other levels.

In most locations, only one or two teachers regularly use the computers in that room. In 60% of classrooms containing computers, only one teacher was reported to be a regular instructional user of the computers in that room. In about half of the laboratories where computers were used for instruction, only one or two teachers were regular users. However, elementary school computer labs and libraries are an exception to this pattern. In a K-6 school, the typical lab is used by six teachers and the typical library containing computers is used by four teachers.

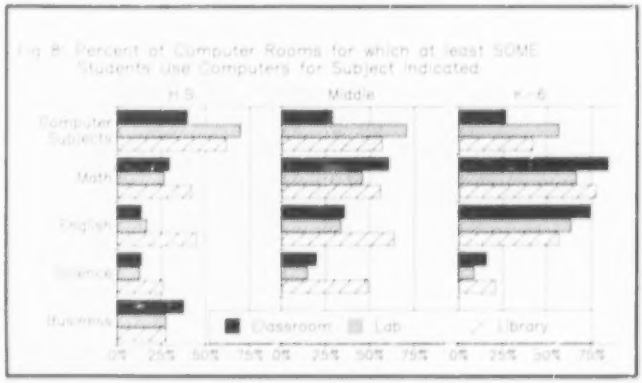
Overall, more computer-using teachers use computers in their own classroom than use them in laboratories, at all three levels of schooling. However, more middle and high school students use computers in lab settings than in classroom settings (Figure 7). Also, the proportion of students who use computers in library settings is much smaller than the proportion of teachers who do so. Thus, teachers tend to use library computers with only a few students.

At a given grade level, subject-matter uses of computers (such as for math, science or English instruction) are more likely than computer literacy or programming activities to occur in classrooms. Computer programming and computer literacy



activity occur mainly in computer labs. Roughly twice as many students study about computers or do programming in computer labs as do these things in classrooms, and at the middle school level the ratio is about 4-1.

However, programming activity is not the primary use of labs in elementary schools, where traditional subjects are the focus of most computer activity. Even in computer labs, more math and English instruction occurs than computer literacy and programming activity (Figure 8). Moreover, above the elementary school level, where laboratory use of computers is more widespread for all subjects, more math and English computer work is done in labs than in classrooms. Of the five high school curricular areas for which data was gathered, only business courses involve more computing activity in classrooms than in computer labs.



Library computers are used for a higher proportion of English (above elementary schools) and science (below high schools) computer work than for other subjects. But, overall, relatively few students at any grade level do their computer work in any subject on library computers.

Table 7: Student Use of Computers in Classrooms, Labs and Libraries by Grade Span of School, Spring, 1985.

Grade Span of School	Median Number of Student Users per Room with Computers			Median Hours of Use per Week Per Computer			Median Minutes per Week of Computer Use Per Student User		
	Class	Lab	Library	Class	Lab	Library	Class	Lab	Library
K-6 Elem.	27	150	50	15	20	15	27	48	24
Middle/Jr.High	30	112	30	15	25	20	28	92	55
High School	35	84	23	20	25	25	80	150	60

Do students get more time to use computers in laboratories?

Computer laboratories are used for more hours of the week than are classroom or library computers, especially in elementary and middle schools. In K-6 schools, laboratory computers are used for an average of 27% more time per week than are computers in either classrooms or libraries. (The means are 20.9 hours per week for labs, 16.4 for classrooms and 16.4 for libraries; the medians are 20 hours per week for labs, 15 hours for classrooms and 15 for libraries.) In middle schools, laboratory computers are used for 25% more time than are those in classrooms (the medians are 25 hours vs. 15 hours per week) and for 10% more time than are library computers.

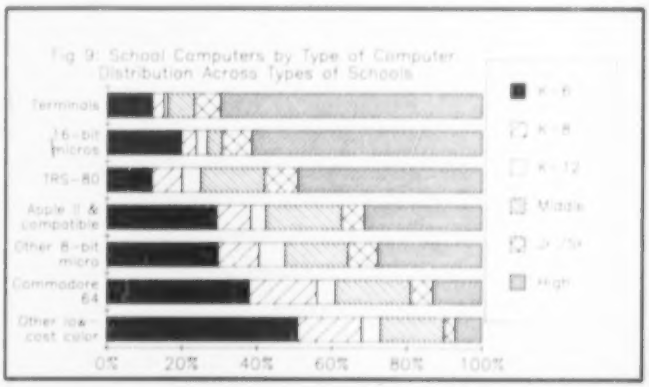
At the high school level, total time of use per computer is roughly the same in labs, libraries, and classrooms. However, the median lab computer is used for 5 hours more per week than the median classroom computer. Table 7 presents medians for a number of dimensions of computer use, including "weekly hours of use per computer," according to the type of room in which the computer is located and the grade span of the school.

The typical student working in a computer laboratory uses computers for about twice as much time as the typical computer user in a classroom. At the middle school level, the difference is 3 to 1. (See Table 7.) This is partly because students doing programming use more computer time than students doing C.A.I., and lab locations and programming tend to be associated. However, even holding constant the subject-matter for which computers are used, students using computers in laboratories appear to have as much as one-third more computer time than students using computers in classrooms. (This conclusion is imprecise, though, because these data were collected on how computers in each room were used rather than how each student used computers.)

What kinds of computers are in which levels of schools?

What schools can do with computers is constrained by the models of computers that they have, and the software and instructional materials available for those models. (Of course, schools choose particular models, in part, because of the curricular plans they have for them, so causality goes both ways.) Rather than categorize schools by the brand names of their computers, we have clustered computers on the basis of the kinds of activities which they and the software available for them make possible.

Figure 9 shows how several categories of computers are distributed across schools of various grade spans. (Although brand names appear in the



figure, the categories go across commercial brands. For example, Apple III and Commodore CBM are grouped with "other 8-bit micros" rather than with the Apple II and Commodore 64, respectively, and the Radio Shack Color Computer is grouped with "other low-priced color computers" rather than with the TRS-80 series.) The figure shows that most types of computers are confined primarily to either upper- or lower-grade level students. High schools and junior-senior highs together have 58% of the TRS-80 (models I, III, and 4), 70% of the 16-bit computers, and 76% of the mini- and mainframe terminals. In contrast, 56% of the Commodore 64's and 68% of the other low-priced color computers are found at elementary schools. Apple II-compatible computers are spread throughout elementary and secondary schools, constituting between one-half and three-fifths of the computers used in each of the six groups of schools in the figure.

HOW THE STUDY WAS CONDUCTED

The Sample

The schools selected for this survey are a stratified probability sample of 2,361 U.S. public and non-public elementary and secondary schools. (The sample did not include pre-primary schools or continuation high schools.) The sampling frame used for the study was the universe file of 100,625 schools belonging to Quality Education Data (QED), of Denver, Colorado. In order to provide the most detail possible about schools making varied and extensive uses of computers, schools with higher grade levels and schools expected to have more computers were oversampled. The sample includes 723 "K-6" schools, 251 "K-8" schools, 374 middle and junior high schools, and 1,013 schools enrolling high school students (some also containing younger students such as in K-12 and 7-12 multi-level schools). All analyses use a "reweighting" of the raw results so that the reported results may be interpreted as coming from a representative sample of all schools in the United States.

Source of The Survey Information

Information about how computers are used in schools was supplied by principals and computer-using teachers. The principal supplied 12 pages of background data as well as basic information about each computer-using teacher (up to 12) on a "Table of Computer-Using Teachers." A second survey booklet was completed by the person identified by the principal as the teacher or staff member most knowledgeable about how the school's computers were used. This "Primary Computer-Using Teacher" (PCUT) questionnaire was an 18-page booklet that requested extensive information about computer use in the school.

Also, up to four other computer-using teachers and administrators provided detailed information about instructional uses of computers in the classes that they taught. Each "User" completed one of seven different 14-page booklets tailored to the subject-matter for which that teacher used computers. Where the school had more than four "Users," computer-using teachers were sampled with varying probabilities in order to obtain the broadest range of school subjects and instructional applications possible (again, with data reweighted for analysis). Finally, in some schools a "non-computer using teacher" gave us attitudinal and teaching practice data that could be compared with the information given by the computer-using teacher at the same school.

Response Rates

Information about whether or not students at the school used computers was obtained for all but 14 schools. Of the 2,146 schools where students did use computers, the "Table of Computer-Using Teachers" was completed (either by mail or by telephone follow-up) for 2,101 schools (98%). The "Primary Computer-Using Teacher" questionnaire was completed by mail at 69% of the schools, and a subset of this instrument (approximately one-third of the questions) was completed by telephone for most remaining schools, bringing the overall response rate up to 92%. "User" questionnaries were completed by mail at a slightly lower rate than for "PCUTs" (about 60%), but telephone calls to a 1/5 subsample of non-respondents brought the effective response rate for teacher-users to 88% for those questions included in the telephone interview. 69% of the principals' own questionnaires were completed by mail, and the effective response rate for this instrument, including telephone follow-up subsampling, was 97%.

SPONSORSHIP AND ENDORSEMENT

The data were collected through funds provided by the National Center for Education Statistics and the National Institute of Education. The survey was endorsed by eleven major education and computer-related national associations: the National Association of Elementary School Principals, the National Association of Secondary School Principals, the National Education Association, the American Federation of Teachers, the National Catholic Educational Association, the American Association of School Administrators, the National Council of Teachers of Mathematics, the American Association of School Librarians, the International Council for Computers in Education, the Association for the Development of Computer-based Instructional Systems, and the Association for Educational Data Systems.

The analysis of these data is being supported by an institutional grant to the Johns Hopkins University's Center for Research on Elementary and Middle Schools from the U.S. Department of Education's Office of Educational Research and Improvement and by a grant from the Studies and Analyses Program of the National Science Foundation's Directorate for Science and Engineering Education. Any opinions expressed do not reflect the policy of these agencies and no official endorsement should be inferred.

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The 'Instructional Uses of School Computers' Newsletters -- What's Next?

The next issue of this newsletter examines differences between schools and students in how they use computers — differences between high- and low-achieving students, between boys and girls, and differences among cities, suburbs, and rural parts of the country. Issue 2 also looks at the perceptions of teachers and principals about the consequences of computer use for their students and schools.

Issues 3 through 6 will focus on specific uses of computers in a variety of curricular areas: mathematics, science, writing, language arts and reading, computer literacy, computer programming and problem-solving, social studies, and vocational programs. In contrast to the more global assessments and statistics presented in the first two issues, the data in issues 3 through 6 will come principally from individual teachers about their use of computers with particular classes of students. Both elementary and secondary schools will be covered in each issue.

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Instructional Uses of School Computers

Reports from the 1985 National Survey Issue No. 2, August 1986

Center for Social Organization of Schools The Johns Hopkins University

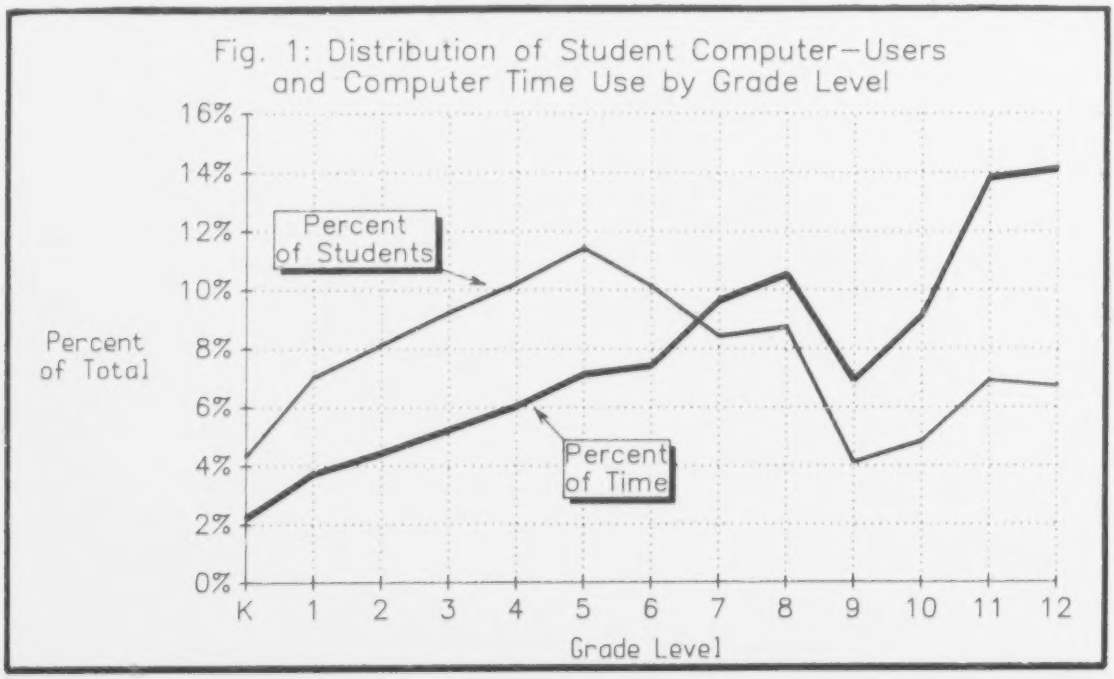
Henry Jay Becker, Project Director

Is there a fair distribution of computer resources across different groups of students in U.S. schools? That is not an easy question to answer. Fairness does not necessarily imply that all students use a particular resource equally, because the needs and interests of students differ. Some students may profit more from using computers than others. However, data about how equally computer resources are distributed will contribute to understanding the fairness or equity of computer use in schools.

In this report, the second of six to be issued from the Second National Survey of Instructional Uses of School Computers, we present data on how computer access and use differs across different grade levels, between male and female students, among high-, average-, and low-achieving students and classrooms. We will also report differences in the use of school computers across different types of communities from farming communities to high-income metropolitan neighborhoods to schools mainly enrolling minority students.

Figure 1 is our starting point. It shows how all school computer time (the thick line) and all student users (the thin line) are divided among each grade level from kindergarten through the 12th grade. In the previous newsletter, we had indicated that the proportion of students who used computers was greatest for elementary schools and lowest for high schools, but that the amount of computer time spent by each student user was much greater in high schools than in middle or elementary schools. Figure 1 shows similar results, but it contains some interesting data for individual grades within these broad levels of schooling.

Fig. 1: Distribution of Student Computer-Users and Computer Time Use by Grade Level



At the elementary level, both the number of student users and the total amount of use increase for each grade from kindergarten to grade five. Thus, substantially more fifth graders used computers in 1985 than did first graders, and fifth graders got nearly twice as much computer time in the aggregate than did first graders. At the middle school level, the total number of student users declines, but the total computer time used by students goes up sharply between the 6th and 7th grade.

At the high school level, both measures of use in Figure 1 shift sharply. At grade nine, substantially fewer students spend substantially less time using computers than in the previous grade. In all, about the same number of 9th grade students use computers as kindergarteners, and their aggregate computer time is equivalent to the time spent by fourth or fifth graders. High school computer use, as Figure 1 shows, is clearly dominated by juniors and seniors. The top two grades comprise 60% of the high school users and occupy nearly two-thirds of the instructional time on high school computers.

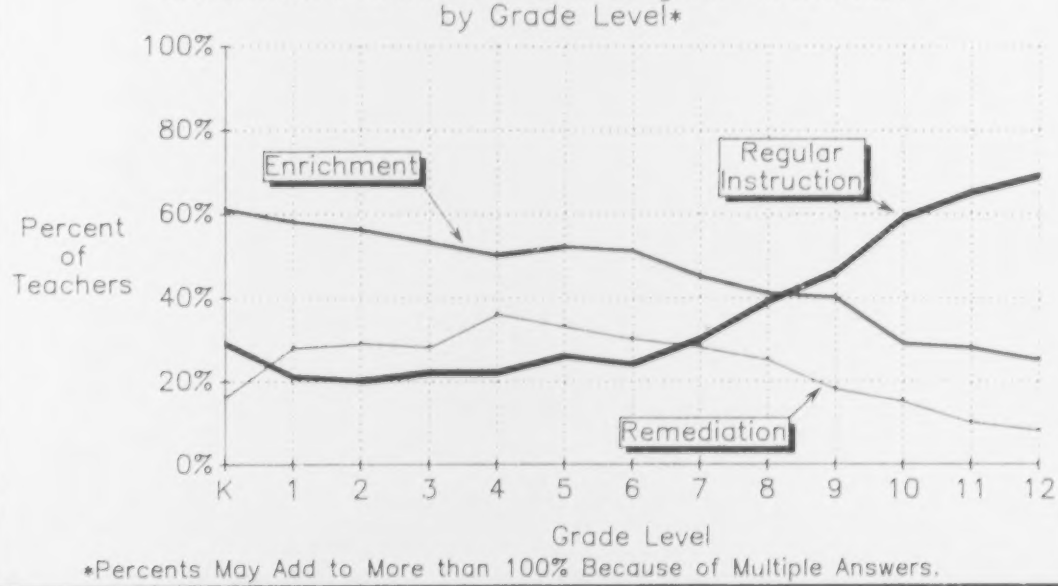
Regular Instruction, Remediation or Enrichment

In each classroom at every grade, some activities are more central to that class's instructional focus than are others. How central a role do computers play in instruction at different grade levels? We asked teachers about their use of computers for one (randomly sampled) class or subject. Our respondents were asked whether computer use for that particular class was a regular part of instruction in that subject or whether instead computers were used primarily for "enrichment" or for "remediation." (A few gave more than one answer.) Figure 2 shows how the teachers' responses differed by grade level.

From kindergarten through the 8th grade, the most common response was that computers were used primarily for enrichment. A majority of teachers from kindergarten through the sixth grade gave this response as did two-fifths of teachers of seventh, eighth and ninth grade classes. Computers also play a remediation role from the first through the seventh grade, but never does remediation represent much more than one-third of all computer use.

Until the secondary grades, computers are seldom seen as integral to class instruction. Only for the high school grades were computers seen primarily as a regular part of instruction. Yet this was clearly the main function of computers in the eleventh and twelfth grades, where high school use was most common. The proportion of teachers indicating the "regular instruction" role for computers shot up dramatically from 39% for eighth grade classes to 59% for 10th grade classes to 69% for twelfth grade classes.

Fig. 2: Function of Computer Activity for Teachers-- Enrichment, Remediation, or Regular Instruction-- by Grade Level*



*Percents May Add to More than 100% Because of Multiple Answers.

Thus, while more students use computers at the younger grades, high school students who do use computers use them for much longer periods and more often as a regular part of class instruction. The high school class is most often a class about computers rather than a class using computers as an instructional medium or a productivity tool, but high school is the one level where computers most often function as an integral rather than a supplementary part of the subject taught.

Differences between Boys and Girls

Computer use also differs substantially between boys and girls, although not everywhere and not in all respects. Table 1 presents some global assessments of the proportion of student computer-users who are girls. Figures are shown for various ways of using computers and for different school levels — K-6 (or K-5) elementary schools, middle (or junior high) schools, and high schools.

For each aspect of computer use (before or after school, word-processing, elective computer programming classes, computer game playing, and overall use) the table shows the median percentage of users who are girls (among schools reporting that kind of use). The median gives the "typical" share of computer use going to female students. But this share varies substantially across schools, so Table 1 presents two other sets of statistics. The columns titled "20th percentile" report a statistic about the schools with the least female participation in that type of computer use. Specifically, it shows the maximum "percent female" among the 20% of schools with the lowest proportion female among computer users. The columns titled "80th percentile" provide data about the 20% of schools with the highest proportion female (the minimum percent female among the schools in the "top 20%").

The medians indicate a rough parity between boys and girls for two aspects of computer use at all three school levels. Overall use and word-processing, on average, are activities where the participants are roughly 50% boys and 50% girls. In addition, playing computer games involves as many girls as boys in elementary school, but not in middle or high school.

Somewhat surprisingly, considering the conventional wisdom on the subject, enrollments in elective programming classes in the middle and high schools in our sample were also roughly evenly split between male and female students, with the typical school reporting 45% female in these activities. We confirmed this result with more detailed information from high school computer programming teachers on the composition of the programming classes that they taught. Girls typically constituted 50% of the students in high school programming classes requiring algebra or higher mathematics as a prerequisite, but they were only 40% of the students in courses without a substantial mathematics prerequisite and 42% in the typical "advanced" programming class.

On the other hand, most computer-using schools reported substantial male dominance in several other areas. In schools where the computer was used either before or after school, boys outnumbered girls three to one. At the typical middle school, for example, only 15% of the before- or after-school users were girls. Boys also dominated elective programming activities in

Table 1: Distribution of Computer Use by Girls for Elementary (K-6), Middle, and High Schools as Reported by Each School's Primary Computer-Using Teacher, Spring, 1985.

	Median Percent Use by Girls (50th Percentile)			Low Percent Use by Girls (20th Percentile)			High Percent Use by Girls (80th Percentile)		
	Elem. (K-6)	Middle School	High School	Elem. (K-6)	Middle School	High School	Elem. (K-6)	Middle School	High School
Overall Use	50%	50%	50%	50%	40%	35%	50%	50%	50%
Before/After School	30%	15%	20%	0%	1%	3%	50%	50%	50%
Word Processing	50%	50%	60%	0%	6%	45%	50%	50%	80%
Elective Programming	9%	45%	44%	0%	20%	30%	50%	50%	50%
Game Playing	50%	30%	10%	20%	5%	2%	50%	50%	40%
Use Index*	45%	38%	40%	30%	26%	29%	50%	50%	51%

*Additive index of non-missing entries on previous five aspects of use.

elementary school and game-playing in middle and high school.

In all aspects of computer use measured, male users outnumbered females in at least some schools. (See the columns titled "20th Percentile" in Table 1.) In contrast, there were very few schools where girls were dominant in any area, except in high school word-processing. (Most high school word processing occurs in business education courses where girls comprise most of the enrollment.) The right-most columns of Table 1 show that -- except for word-processing -- the 20% of schools with the greatest female participation still show almost uniformly a 50-50 split between boys and girls. Thus, disproportionate use of computers by boys occurs frequently, whereas disproportionate use by girls is almost non-existent.

Our survey asked individual computer-using teachers about the sex distribution of the computer-using students who they themselves had taught. In particular, we asked these teachers to indicate the sex of the "three students (who) have been most affected by their experience with computers in school." About 38% of the students identified by elementary school teachers were girls; 62% were boys. At the secondary school level, teachers named even fewer girls. Females were only about one-third of the secondary school nominees. Moreover, the first person named by each teacher was overwhelmingly likely to be a boy -- 74% at the elementary level and 78% at the secondary level.

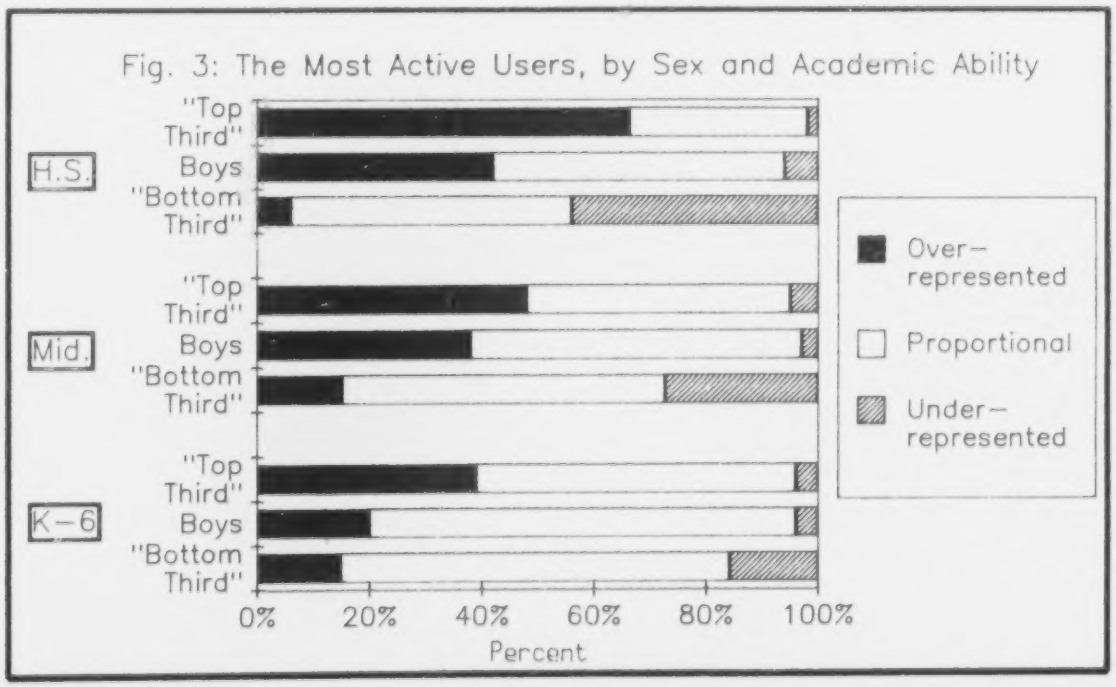
Yet when asked HOW computers had affected these students, elementary and middle grade teachers who had named a girl were more likely to say that computers had helped her academically. Male elementary and middle grade nominees were more likely to be affected in terms of behavior and attitudes -- such as improvements in self-confidence, self-discipline, or motivation.

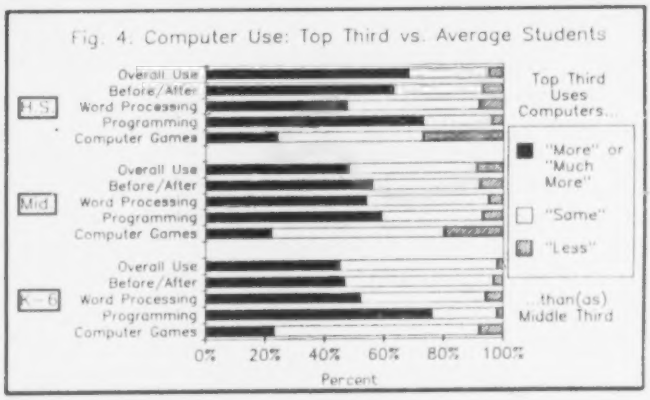
Differences by Student Ability

As much as boys dominate computer use, higher-ability students use computers at least as disproportionately. Figure 3 shows one example of this. Each school's "primary computer-using teacher" was asked to think of the dozen or so students who "most actively use school computers" and to report roughly how many of them were in the top-third of their class, how many were in the bottom-third, and how many were female.

At all school levels, more respondents said that the "top-third" students were overrepresented among the most active dozen than indicated that "boys" were overrepresented. "Bottom-third" students were overrepresented about as often as they were underrepresented in elementary schools, but they were more often underrepresented in middle schools and even more underrepresented in high schools.

Figure 4 provides other evidence about the dominance of upper-ability students in most types





of computer activities at all school levels. Compared to average students (those in the "middle-third" of their class), "top-third" students used computers more overall, more before- and after-school, more in word-processing, and much more in elective programming. Upper-ability students did not, however, dominate in the playing of computer games.

The use of school computers affects upper-ability and lower-ability students differently. In identifying students who were most affected by using school computers, teachers responded very differently for students whose school performance was "high" or "very high" than they did for students they identified as doing less well in school. Figure 5 summarizes these differences.

By far the most frequently reported effect of computers on lower-ability students was in improved motivation, self-confidence, and self-discipline. These behavioral and attitudinal consequences were mentioned much less often for higher ability students, particularly at the high school level. In contrast, teachers reported that computers helped higher-ability students primarily with higher-order thinking skills, programming skills, writing, science projects, out-of-school activities, career preparation, real-world experience, and other activities which the figure labels "high ability academic direction." Lower-ability students also received academic help from their computer work but primarily for developing basic skills in mathematics, reading, and language.

Computer Use for School Subjects, by Grade Level

Computers may affect students of different academic abilities differently in part because such students use computers for different school subjects. This section examines how computers are used by school subject, first by grade level and then by the ability-level of classes within the same grade span.

The first newsletter briefly discussed the distribution of computer use by subject-matter in

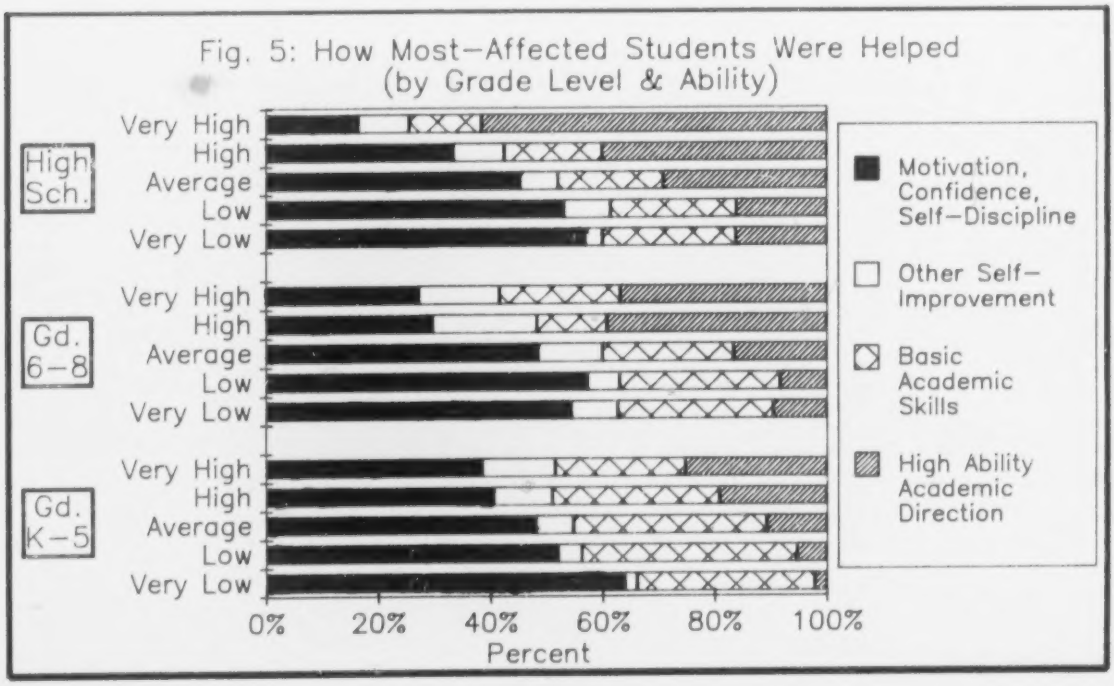


Table 2: Distribution of Computer Use, by Subject and Grade Level, Spring, 1985.*

SUBJECT (from course title, activity, and software in use)	GRADE LEVELS OF STUDENTS IN CLASS K-3	4-8	9-12
Mathematics**			
Topics below algebra or unspecified math	42%	27%	5%
Algebra, geometry	0%	1%	1%
Trig,. advanced math	0%	0%	1%
Subtotal: traditional math subjects	42%	28%	7%
English			
Language arts and spelling	18%	12%	4%
Reading	17%	8%	2%
Subtotal: language arts	35%	20%	6%
Writing	2%	2%	3%
Word processing in English class	3%	3%	2%
Subtotal: writing	5%	5%	5%
Computers and Problem-Solving			
Math topics: problem-solving, logo, programming activities	3%	6%	2%
Programming*** as specific topic or course	2%	13%	42%
Logo as specific topic****	4%	5%	1%
Computer literacy as specific topic or course	6%	10%	5%
Subtotal: computers & problem-solving	14%	34%	50%
Business and Word Processing			
Business, accounting, secretarial, other than word processing	0%	0%	6%
Word processing, other than in English	1%	2%	12%
Subtotal: business	1%	2%	18%
Other Subjects			
Science and nutrition	1%	3%	7%
Social studies	1%	4%	1%
Industrial arts and agriculture	0%	1%	5%
Others	2%	2%	2%
Subtotal: other subjects	4%	11%	15%
Total for All Subjects	100%	100%	100%

*Sum of individual entries may not equal subtotal entry because of rounding. Similarly, subtotals may not sum to grand total.
**See also first entry under 'Computers.'
***Excludes specific mentions of Logo.
****Includes some general problem-solving not classified elsewhere.

the context of showing how lab and classroom environments differ. Here we look specifically at the subject and topic of instruction. Table 2 presents results by grade level, but we have collapsed the thirteen grades into three categories: early elementary (K-3), late elementary and middle (4-8), and high school. The data is from one randomly sampled class or subject taught by each computer-using teacher. In particular, the data refer to the computer activity most recently engaged in by students in that class. Each class is weighted according to how much it used computers during the year, so percentages give the approximate proportion of total use.

In grades K-3, whole number arithmetic and language arts, including spelling and reading, constituted three-quarters of all use of computers. (41% for arithmetic; 35% for language arts.) This includes time spent during "computer literacy" units where students were engaged in math or language drills. General instruction about computers, programming, use in teaching logic and problem-solving skills and use in writing together constituted only about 20% of the time spent with computers by K-3 students.

At the other age extreme, in grades nine through twelve, one-half of all student computer activity was concentrated in computer programming (and some computer literacy) courses and topics. Another 19% was spent in business, typing, and word-processing courses (outside of writing courses in English). There was relatively little use in traditional mathematics subject-matter (7% of all high school computer activity) or science courses (7%), and English activity was split between language arts drills and tutorials (6%) and writing activities (5%). The aggregate proportion of time on computers in industrial arts and agriculture classes (5%) was roughly the same as that for mathematics, science, language arts, or writing.

Perhaps the most diverse use of computers in the survey appeared in the late elementary and middle grades. There was substantial use for arithmetic, algebra and other traditional math topics (28%) and significant use in language arts and reading (20%). But there was also substantial use for subjects where the computer was primarily the object of instruction rather than the means of instruction. Computer literacy (including "logo" activities) occupied about 15% of middle-grade computer time and more conventional instruction in programming languages occupied another 13%. Additional computer time was spent on higher-order problem-solving skills in math (6%), writing and word-processing (7%), and use in social studies (4%) and science (including nutrition, 3%).

High-Ability, Mixed-Ability, and Low-Ability Classes, Grades 4-8

In the middle grades and in the upper grades, how computers were being used differed widely according to the ability levels of the students enrolled in the class. Each computer-using class sampled in the survey was categorized as enrolling (a) primarily very high ability or "gifted" students, (b) primarily very low ability or learning disabled students, or (c) average students or students of mixed academic abilities. Only teacher- or school-designated special classes were distinguished, so that most computer-using classes were in the "average" or "mixed" category. Table 3 shows the distribution of computer activities by subject, as in Table 2, but separately for low-, mixed-, and high-ability classes. The first three columns contain data for grades 4 through 8; the last three, for high school grades.

The pattern of computer use in low-ability classes in grades four through eight strongly resembles the overall pattern for all classes in kindergarten through grade three. (Compare with Table 2.) Three-quarters of computer activity in these classes emphasizes basic math and language arts skills. These classes do not share the emphasis on computer-specific and higher-order skills found at the same school level in mixed-ability classes and even more so in high-ability middle-grade classes. (These statistics, though, refer to classes rather than individual students. It is possible that many students in low-ability math and English classes are re-grouped into heterogeneous classes for computer topics and problem-solving.)

In the middle grades, computers are much less often used in language arts instruction in mixed- and high-ability classes than in low-ability classes. They are also much less prevalent in high-ability math classes (on math topics) than in mixed- or low-ability classes. High-ability classes in these grades make more use of computers for writing than do other classes, but writing occupies only about 10% of the computer time of these high-ability classes. Social studies and science (primarily in the form of programs about nutrition) make up another 10% or so of computer use in high-ability classes.

However, it is computer programming that stands out as the most substantial aspect of high-ability classes' use of computers in the middle grades. Programming, computer literacy, and problem-solving activities account for 60% of the computer time in these classes. Altogether, two-thirds of the class computer time is devoted to higher order thinking, writing, and programming activities for high-ability groups. In contrast, these uses take up only about 40% of the computer time for mixed-ability classes and less than 20% for low-ability classes.

Table 3: Distribution of Computer Use, by Subject and Ability Level, Upper-Elementary through High School, Spring, 1985.*

	GRADE AND ABILITY LEVELS OF STUDENTS IN CLASS					
	Grades 4-8			Grades 9-12		
SUBJECT (from course title, activity, and software in use)	Low(29%)	Mixed(59%)	High(12%)	Low(13%)	Mixed(78%)	High(9%)
Mathematics**						
Topics below algebra or unspecified math	36%	27%	9%	32%	1%	0%
Algebra, geometry	2%	1%	3%	1%	1%	2%
Trig,. advanced math	0%	0%	0%	0%	1%	3%
Subtotal: traditional math subjects	38%	28%	12%	32%	3%	5%
English						
Language arts and spelling	20%	10%	4%	16%	2%	1%
Reading	19%	5%	2%	13%	0%	2%
Subtotal: language arts	39%	15%	6%	29%	2%	3%
Writing	5%	1%	6%	4%	2%	9%
Word processing in English class	1%	3%	4%	5%	1%	5%
Subtotal: writing	6%	4%	10%	9%	3%	14%
Computers and Problem-Solving						
Math topics: problem-solving, logo, programming activities	4%	6%	10%	3%	1%	2%
Programming*** as specific topic or course	2%	14%	25%	4%	50%	32%
Logo as specific topic****	3%	6%	8%	2%	1%	1%
Computer literacy as specific topic or course	4%	12%	18%	6%	5%	4%
Subtotal: computers & problem-solving	13%	38%	61%	15%	57%	40%
Business and Word Processing						
Business, accounting, secretarial, other than word processing	0%	1%	0%	0%	7%	2%
Word processing, other than in English	2%	1%	2%	6%	13%	11%
Subtotal: business	2%	2%	2%	6%	20%	13%
Other Subjects						
Science and nutrition	1%	5%	2%	2%	6%	18%
Social studies	0%	6%	6%	3%	1%	3%
Industrial arts and agriculture	0%	1%	0%	2%	7%	0%
Others	2%	3%	3%	3%	2%	3%
Subtotal: other subjects	3%	14%	10%	9%	15%	24%
Total for All Subjects	100%	100%	100%	100%	100%	100%

*Sum of individual entries may not equal subtotal entry because of rounding. Similarly, subtotals may not sum to grand total.
**See also first entry under 'Computers.'
***Excludes specific mentions of Logo.
****Includes some general problem-solving not classified elsewhere.

Mixed-ability computer-using classes in the middle grades suffer from a poorer ratio of students to computers than do either low- or high-ability classes. The mixed-ability classes tend to be somewhat larger than the gifted classes (and much larger than the special education classes), and they have fewer computers available to them. Where classes use computers in their own classroom rather than in a separate lab (and about three-fifths of the classes in these grades do), mixed-ability classes have a median ratio of 20 students per computer. So, they typically have only one or two computers in their classroom. High-ability classes using computers in their room have a median 10-1 ratio, and low-ability classes typically have an even better 5-1 ratio. High-ability classes are more likely than either of the other types to use computers outside of the classroom, in a laboratory or library, where the student-to-computer ratio is much better (typically 1-1).

Students and teachers in high-ability classes are more likely to have a computer at their own home than are other middle grade computer-using students and teachers. Among teachers of the high-ability classes, 47% have a home computer compared to 28% of the other computer-using teachers. And in more than 90% of the high-ability classes, at least three students have a home computer. This compares with about 60% for the mixed-ability classes and only 20% for the low-ability classes (which, however, have fewer students). On the other hand, substantial experience in formal teacher training does not markedly distinguish computer-using teachers of the high-ability classes from those of mixed- or low-ability classes. They are only modestly more likely to have had 50 hours or more of training in using computers for instruction (32% vs. 25%).

Class Ability Levels -- High School

In high school, low-ability classes continue to use computers primarily for pre-algebra mathematics and for language arts skills. The mixed-ability classes are heavily concentrated in computer programming, business, and word-processing. More than three-quarters of their activity is in these areas. Only 6% of the computer work in average or mixed-ability classes is in science, only 3% in traditional mathematics coursework, 3% in writing, and only 2% in language arts. Interestingly, a smaller proportion of "high ability" high school computer classes involves programming than is the case for "mixed-ability" classes (32% vs. 50%). More detailed information about the classes indicates that students enrolled in typical high school programming classes are generally "higher than average" in ability, but only a very small minority of these classes have mainly "very high ability" students. Consequently, few programming classes qualify for the "high ability" category of Table 3.

High-ability high school classes use computers in writing and in science much more than do mixed- or low-ability classes. Together, writing and science constitute about one-third of the computer work of high-ability high school classes. Relatively little of the computer work of high-ability classes is for advanced mathematics courses (5%).

That students in different academic ability groups use computers so differently is not surprising. Nor is it necessarily inequitable. It merely indicates that computers permit a great variety of instructional activities and that the educational needs of different students vary. But computer tasks vary among students also because some computer applications and much of the available software requires students to confront and solve operational problems and make decisions without close adult supervision, and some students are more able to do that than others. Extending to less able students applications that emphasize higher-order thinking and problem-solving requires software that is comprehensive and easy to use. Provision also must be made for the time that students spend awaiting their turn on the computer.

On the other hand, we encountered some unexpected areas of the curriculum that employed computers in a relatively minor way. In particular, our survey found that in 1985 there was little use of computers in mathematics classes beginning with algebra, particularly in the highest level high school mathematics courses, such as trigonometry. Also, use of computers in secondary science and social studies courses was mainly limited to advanced high school science courses in physics, chemistry, and biology, and to using simple simulation games in middle-school social studies courses.

Computing Across the U.S.: Computer Use by Community Type

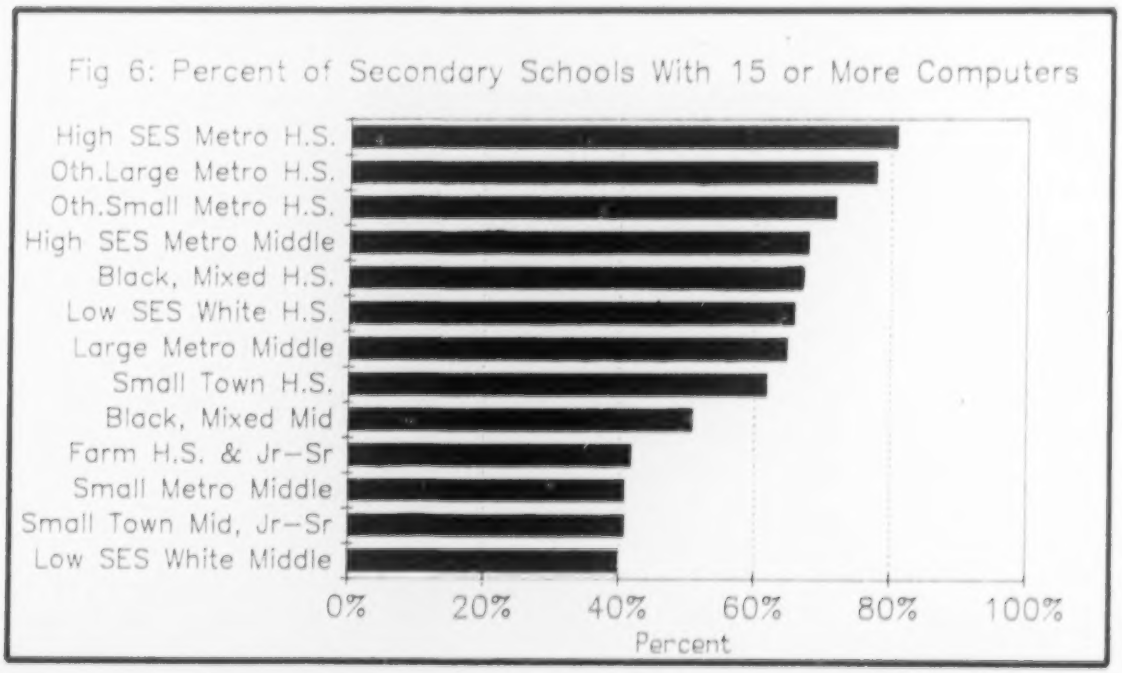
As we have seen, student grade levels and school performance levels both significantly affect the type of computer experience offered by the school. The type of community where a student lives also affects a student's access to computer time and affects how that student is likely to use computers.

In this section, we examine seven groups of schools classified by the community where the school is located and the socio-economic characteristics of students who attend them. The seven groups of schools are: (1) schools where many students come from relatively high socio-economic backgrounds and which are located in metropolitan areas (here called "High SES schools"); (2) schools located in metropolitan areas and that have a racially mixed or predominantly minority student body ("Black/Mixed schools"); (3) metropolitan area schools that are primarily white and non-Hispanic but where students typically come from a low socio-economic background ("Low SES schools"); (4) other schools in metropolitan areas of over one million people ("Large Metro schools"); (5) other schools in smaller metropolitan areas ("Small Metro"); (6) schools where most students are from farm families ("Farm"); and (7) other schools in areas outside of metropolitan areas ("Small Towns").

By 1985, most elementary schools used at least one computer for instruction. High SES schools and K-6 schools in smaller metropolitan areas were the most likely to have a computer -- roughly 90% did. Farm schools, low SES K-8 schools, and racially mixed and minority elementary schools were the least likely to have a computer. Nevertheless, even three-quarters of those schools had a computer.

On the other hand, few elementary school students attended a school that had at least 15 computers -- enough to serve perhaps one-half or one full class at the same time. Fewer than one-fifth of the students in elementary schools in large metropolitan areas or high SES schools attended a school with that many computers in 1985, and these were the types of schools MOST likely to have 15 or more computers. Thus, geographic location and socio-economic variables probably did not significantly affect overall access of elementary school children to computers in 1985.

Among secondary schools, these community characteristics appear more relevant to computer access. (See Figure 6.) Certain types of secondary schools were far less likely to have had 15 or more computers in the Spring of 1985 than were other types of schools. In particular, 15 or more computers were available in only about 40% of low SES middle schools, small town middle and junior-senior highs, small metropolitan area middle schools, and high schools and junior-senior highs in farming communities. In contrast, two-thirds of high SES middle schools, and about four-fifths of large metropolitan area and high SES high schools



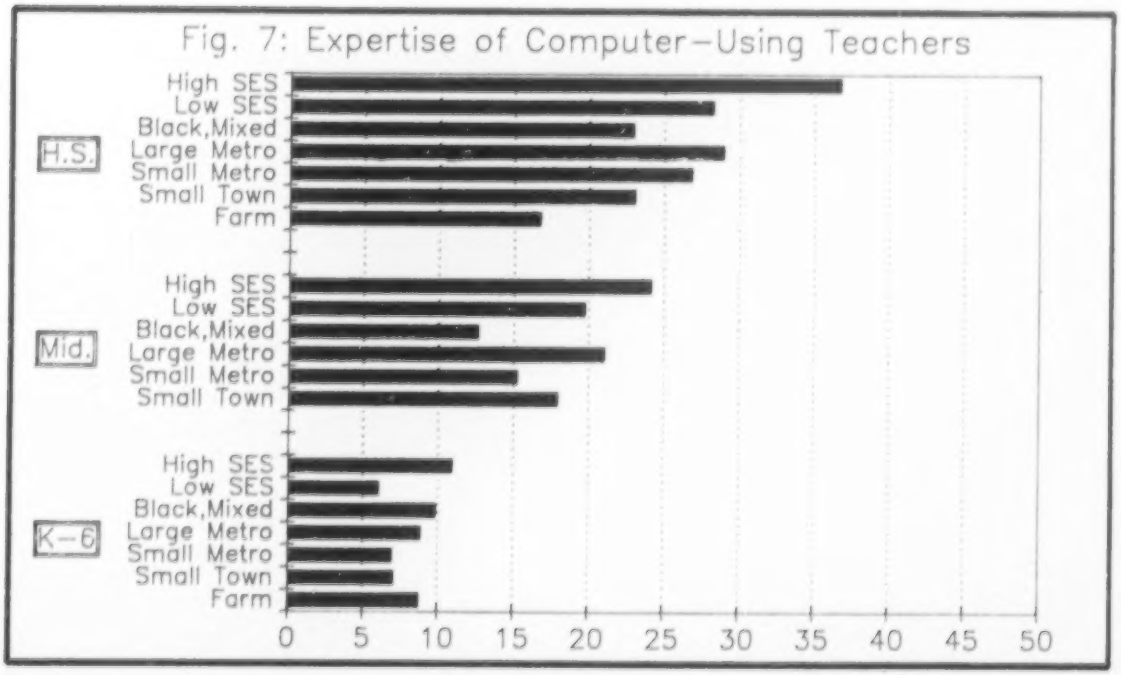
had 15 or more computers. Actually, the seven community types differed less in their typical "student-to-computer" ratios than in the likelihood that they had 15 computers. But for schools, where the organizational problem of serving classrooms of students is paramount, having 15 computers might be a reasonable minimum for serving students in instructional groups, regardless of student-to-computer ratios.

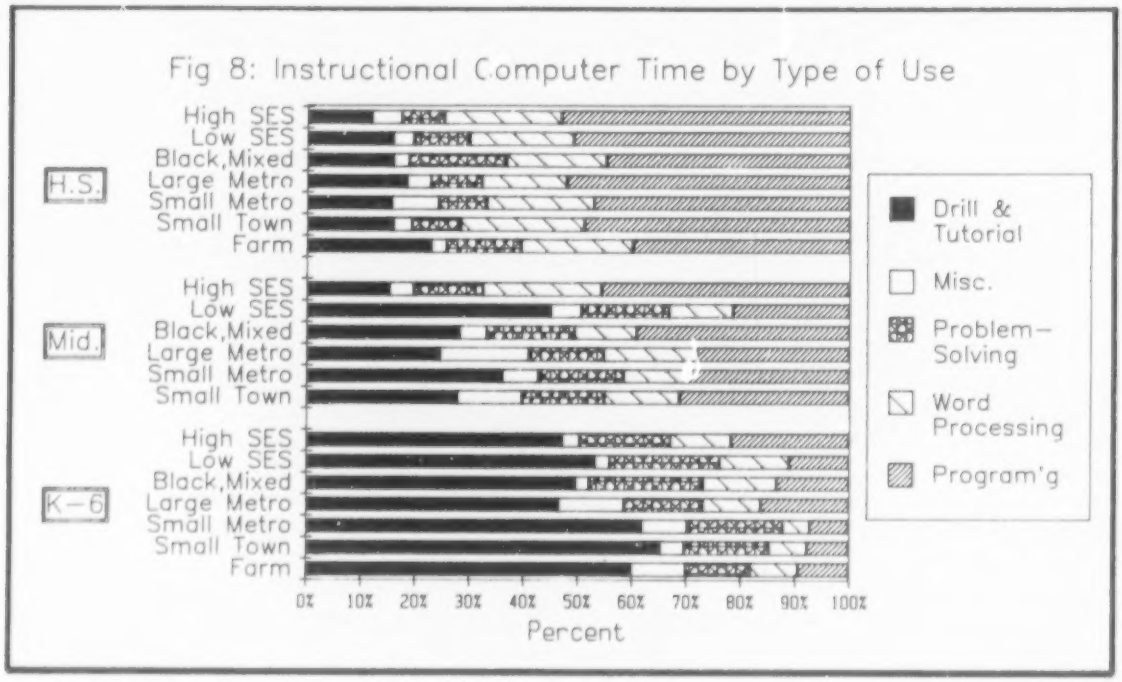
Of course, without teachers knowledgeable about using computers, having many computers is no advantage. Our study measured the expertise of computer-using teachers in two ways, but we refer here only to one of them: a report by each school's primary computer-using teacher of the number of teachers who were "expert" in (a) using instructional programs, (b) knowing about a wide variety of programs, (c) using computers as a professional tool, and (d) having programming skills. Figure 7 shows the average "expertise" index (on a scale from 0 to 100) of computer-using teachers at schools categorized by grade span and type of community.

As reported in the previous newsletter, few computer-using elementary teachers are "computer experts." This is understandable considering the broad instructional responsibilities of elementary school teachers. Consequently, differences in teacher computer-expertise are generally small across elementary schools in different types of communities. But at the secondary level, schools in some types of communities have a higher proportion of experts among their computer-using teachers than do schools elsewhere.

Computer-using teachers at High SES high schools have more expertise than those at other high schools. High schools in farming communities are staffed by less expert computer-using teachers. High SES middle school computer-using teachers also are more expert than teachers at middle schools in other types of communities. Other communities have basically similar patterns of teacher computer expertise.

We saw earlier that, starting in the upper elementary grades, high-ability classes of students use computers for different academic purposes than do students in mixed-ability and low-ability classes. Although there are some high-, average-, and low-ability classes in schools in all types of communities, the aggregate pattern of computer use in schools is likely to be affected somewhat by aggregate differences in how well students in these communities do academic work. However, between-





community differences in how computers are used in schools may also reflect other factors, such as teacher expertise and the value placed on computer skills in the local culture.

Figure 8 shows the distribution of computer time at schools in various types of communities. The table shows some basic similarities across communities in how schools of the same grade span allocate computer time. For example, at the high school level, the proportion of time going to programming activities varies only from 40% for high schools in farming communities to 53% for high SES high schools. The remaining groups of high schools are in the narrow range of 45% to 52%. The proportion of time going to word-processing in high school varies only between 16% and 22% among the seven types of communities.

But in some respects there are rather sizable differences among the communities. Programming in middle and junior high schools varies from occupying 22% of the computer time in low-SES predominantly white middle schools to 46% of the time in the high-SES communities. The other groups of schools are scattered in-between. Correspondingly, computer-assisted instruction ("drills and tutorials") occupies only 15% of the computer time in high-SES middle schools compared to 45% in low-SES predominantly white middle schools.

Among K-6 elementary schools, the proportion of time in drill and tutorial activities varies from a low of 46% ("Large Metro") to a high of 65% ("Small Town") and the proportion of time in programming activities varies from 7% ("Small Metro") to 22% ("High SES"). "Discovery learning and problem-solving" activities occupy 21% of the computer time in racially mixed and minority metropolitan elementary schools but only 12% in elementary schools in farming communities.

Of the various differences indicated in Figure 8, the most consistent one is that more programming activity occurs in schools in metropolitan areas with students from high socio-economic backgrounds. Although these results are shown in terms of an economic variable (SES), more detailed analyses of the data suggests that between-school differences in the ways computers are used are better accounted for by differences in student academic achievement than by socio-economic differences. This is especially so for the differential in programming activities. We only note here that high SES schools lose their distinctive pattern with respect to programming activities when we get to the high school level. At that level, programming courses have moved from the narrow "gifted-and-talented" area to the more inclusive "college prep" track.

Conclusions

Our findings indicate substantial differences in access and use of school computers in terms of student ability and sex. However, as we suggested at the start, equitable allocation of school resources is not merely a matter of giving every student an equal amount of computer time and an identical set of instructional tasks. If students had identical backgrounds, needs, goals, and interests, that might be the case. However, because these assumptions are not true, an equitable allocation of computer use depends upon the relative educational value of computer-based activities for different groups of students needing instruction of different form and content. Concrete evidence about the immediate and longer-term impact of computer-based instruction, computer literacy curricula, and computer applications is clearly insufficient at this time. To know how fair the distribution of computer experience is -- and to know how effective these experiences have been -- we must begin to measure actual consequences for students by systematic field studies of alternative instructional programs.

How effective is computer-based instruction? Our survey data gives us no definitive answers. We did no direct evaluation of student computer users. But we do know how the teachers who provided computer experiences perceived their impact. In the next newsletter, we will report these perceptions of teachers and principals and how the perceived consequences for students differ by the type of computer experience provided. We will also begin our more detailed curriculum-specific coverage with descriptions of how computers are being used with traditional mathematics and science subject-matter.

SUBSCRIPTION INFORMATION

The complete series of six newsletters is available by subscription for $7.50, payable to The Johns Hopkins University. Write to Computer Survey Newsletters, Center for Social Organization of Schools, Johns Hopkins University, 3505 N. Charles St., Baltimore, MD 21218.

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Instructional Uses of School Computers

Reports from the 1985 National Survey Issue No. 3, Nov. 1986

Center for Social Organization of Schools The Johns Hopkins University

Henry Jay Becker, Project Director

What hath the computer wrought? With a million or more computers in use every day in U.S. schools, it seems reasonable to ask what impact computers have had -- on the students, on the teachers, and on the schools themselves.

Potentially, the most important outcomes are improvements in student competencies -- the things they understand and the things that they can do. But measuring the academic consequences of using computers is complicated, and rarely has this been done well, or even done at all. As a survey of teachers, our research could not test students' achievements before and after their computer experiences to measure how they had changed. Nor could we compare students' achievements in classes using computers with those in similar classes providing traditional instruction on the same content. But we could measure teachers' **perceptions** of the effects of the use of computers at their own school and in their own classes.

The validity of these teachers' judgments varies -- some reflecting over-skepticism; others, over-enthusiasm. But by looking carefully at the data (for example, by paying more attention to **relative** perceptions across different outcomes) we can extract strong clues about how learning and instruction in typical classroom settings have been *most* affected by computers and how they have been *least* affected.

This report examines a variety of survey questions that all lead to a common conclusion: As of Spring, 1985, computer-using teachers were excited about the possibilities of using computers and saw significant outcomes occurring mainly in four areas: student motivation, student cooperation and independence, opportunities for high-ability students in programming activities and in other higher-order thinking and writing skills, and oppportunities for low-ability students in mastering basic skills. Nevertheless, the promise of computers was not yet fulfilled for average students, for diagnosing specific instructional needs, for systematic individualization of instruction, or for improving most learning of facts and concepts.

We present two types of survey information in this report. The first several sections present the judgments of principals and primary computer-using teachers ("PCUTs") in more than 2,100 schools in our national sample. They give us their perspective about the impact of computer-use on organizational, social, and academic outcomes at their school in general. The last part of the report presents the opinions of roughly 3,500 computer-using teachers from the same schools about the impact of computers on their own teaching and on students in their own classes.

Note for Readers New to this Series

This is the third of six reports from the Second National Survey of Instructional Uses of School Computers. The results presented are based on questionnaire and interview data from roughly 8,000 principals and computer-using teachers in more than 2,100 computer-using elementary, middle, and high schools, both public and private. These findings represent a statistically representative portrait of computer-using schools in the United States, as of Spring, 1985.

Classroom Social and Instructional Outcomes

Principals and primary computer-using teachers both answered a set of questions about the outcomes of using computers at their school. They indicated whether "as a result of computers," there had been any improvement (or "much" improvement) in such areas as student enthusiasm, peer helping, individualized assignments, diagnoses of learning problems, and learning in regular school subjects by "above-average," "average," and "below-average" students.

These are rather general concepts that reasonable people might disagree about, either because they hold different standards for whether something is "much improved" or because they see these things from the particular perspective of teacher or principal. Not surprisingly, the answers of principals and PCUTs from the same school on most of these items correlated only between .14 and .24, showing substantial differences in judgment. But if we look across all schools of a particular grade span, principals and PCUTs did agree about the outcomes most often experienced and those least often experienced. Table 1 shows the percentages of principals and PCUTs, by school level (elementary, middle, and high school), who indicated that each outcome was "much improved" because of computers.

Across all three school levels, principals and primary computer-using teachers see two areas as most improved: student enthusiasm for the subjects for which they use computers and special opportunities for the academically gifted. In 1983, when we conducted a similar survey, comparable items about enthusiasm and about "above-average" students were also the areas computer-using teachers said were most improved because of computers.

In this survey we asked two separate questions about the "better" students. We asked about "special opportunities for the academically gifted" and about "learning in regular school subjects by above-average students." Although educators reported a great deal of improvement

Table 1: PCUTs' and Principals' Perceptions of Computer Impact: Percent Reporting Outcome "MUCH IMPROVED," by School Level

	K - 6		Middle/Jr.Hi.		High School	
Outcome	PCUT	Prin.	PCUT	Prin.	PCUT	Prin.
Enthusiasm of students for subjects for which computers used.	41%	*	38%	*	40%	*
Special opportunities for the academically gifted.....	28%	40%	36%	42%	29%	43%
Enthusiasm for school in general.....	26%	32%	24%	38%	18%	36%
Special opportunities for the learning disabled.....	24%	28%	26%	30%	15%	19%
Students helping other students with their questions.....	22%	19%	18%	13%	22%	20%
Students working independently without direct supervision.....	18%	21%	16%	17%	23%	23%
Learning in school subjects by below-average students.....	18%	15%	18%	15%	9%	9%
Student assignments tailored to individual needs.....	12%	12%	11%	6%	8%	11%
Learning in school subjects by above-average students.....	11%	16%	6%	9%	4%	11%
Learning in school subjects by average students.....	9%	13%	7%	8%	4%	6%
Diagnoses of students' learning problems or misunderstandings..	5%	4%	6%	5%	2%	6%

* Not asked.

in opportunities for the gifted, they reported very little improvement in academic learning by above-average students, particularly above the elementary grades. This may be because they viewed the "gifted" category as separate from the "above-average" or because above-average middle and high school students use computers mainly for non-traditional academic subjects ("opportunities"?) -- programming, computer literacy, and logic and problem-solving -- rather than for "regular" school subjects like math, science, English, and social studies.

Five other items in Table 1 form a second tier of outcomes seen by principals and PCUTs. Two of these were observed at all levels but more frequently at the elementary and middle school levels ("enthusiasm for school in general" and "special opportunities for learning disabled students"); two were observed somewhat MORE often at the high school level ("students working independently" and "students helping other students with their questions" -- peer helping); and one was reported mainly in elementary and middle schools ("learning in school subjects by below-average students").

As with the items about above-average students, "opportunities" for learning disabled students were reported as more improved than actual learning by below-average students. One explanation is that computers did less to help low-ability students master subject-matter than they contributed to boosting these students' self-esteem -- after all, the students were chosen to use a highly valued piece of school apparatus. Alternatively, "opportunities" may be more easily observed than "learning," and therefore more likely named as having been affected by computers. Still, the perceived impact on learning by low-achieving students reported in this 1985 survey is substantially greater than the impact indicated in our 1983 survey. In that earlier survey, only 7% of the schools reported improved learning outcomes for low-ability students as a result of computers. Even using the more conservative of the items in this 1985 survey, the comparable percentages roughly doubled in two years, particularly at the elementary and middle school levels. None of the other outcome items changed as much in two years.

In our current survey, the outcomes with the least perceived improvement due to computers are individualization of assignments, diagnoses of individual learning difficulties, and learning in regular subjects by average and above-average students. These four areas were at the bottom of the rankings for all three levels -- elementary, middle, and high schools.

Improvements in individualization, attention to diagnoses, and corresponding improvements in academic learning are the kinds of outcomes one might expect if computer-assisted instruction (C.A.I.) approaches were being employed successfully. Computer-assisted instruction does constitute one-third of all computer activity in schools (and even more at the elementary level). But the lack of reported effects on individualization, diagnoses, and academic learning suggests most computer-using teachers and school principals did not see C.A.I. providing a major benefit to students, at least as of 1985.

The lack of impact of C.A.I. may be due to the generally unsystematic way that schools have implemented C.A.I. programs. Few schools have had enough computers to allow half or all of one teacher's class to use programs simultaneously. As of 1985, few schools used a sequence of programs that provided skill practice and instructional dialogue on the full range of objectives covered in a particular course. And few used instructional management systems to direct an individualized sequence of appropriate instruction by diagnosing each student's areas of instructional need.

Differences in Outcomes By Type of School

At all levels, schools with more computers reported more improvement in most outcomes shown in Table 1. For example, among elementary schools, we obtained correlations above .15 between the number of computers at a school and their perceived impact on improving peer helping, increasing use of individualized assignments, and increasing use of diagnoses. Among high schools, the more computers a school had, the more that computers were believed to have improved students' enthusiasm for school in general, increased opportunities for learning disabled students and improved learning by average and above-average students (correlations all between r=.15 and r=.22). Even among high schools with many computers,

however, few schools reported substantial improvement in subject-matter learning because of computers.

Correlations of .15 to .22 may not seem large, but survey measures such as these generally contain a lot of "random error" which generally makes observed correlations substantially lower than their "true" values. Correlations such as these often translate to rather substantial differences in percentage terms. See Table 2 for some examples.

Table 2: Illustrative Relationships between Number of School Computers and Perceived Outcomes of Using Computers*

SCHOOL LEVEL AND OUTCOME	OUTCOME "MUCH IMPROVED" BECAUSE OF COMPUTERS (%) Schools Classified by Number of Computers Used for Instruction 1 - 4	5 - 14	15 +	Correlation Between Outcome and Number of Computers
Elementary (K-6) Schools:				
Students helping other students with their questions	14%	24%	38%	r=.17
Student assignments tailored to individual needs	6%	16%	25%	r=.18
Diagnoses of students' learning problems or misunderstandings	3%	6%	10%	r=.21
Learning in school subjects by below-average students	15%	20%	32%	r=.13
Special opportunities for the academically gifted	26%	29%	45%	r=.17
High Schools Computers:	1 - 8	9 - 16	15 +	
Enthusiasm for school in general	23%	23%	41%	r=.22
Special opportunities for the learning disabled	17%	19%	33%	r=.19
Learning in school subjects by average students	1%	2%	8%	r=.15
Learning in school subjects by above-average students	1%	6%	10%	r=.18

* Percentages shown are based on "much improved" responses from EITHER principal or PCUT with at least partial agreement from the other.)

Several differences in perceived effects were related to how computer time was allocated among possible uses. Middle and high schools that allocated more computer time to word-processing reported more favorable outcomes generally, and in particular for learning in regular school subjects, for opportunities for learning disabled students, for students working independently of supervision, and for students helping each other. Nine of the twelve school-level correlations between those outcomes and the proportion of computer time allocated to word-processing were r=.15 or greater. (Table 3 shows these relationships in terms of percentages. However, by categorizing the variables for ease of presentation, some distinctions become less clear.)

Table 3: Significant Relationships between Allocation of Computer Time to WORD PROCESSING and Perceived Outcomes of Using Computers*

SCHOOL LEVEL AND OUTCOME	OUTCOME "MUCH IMPROVED" BECAUSE OF COMPUTERS (%) Schools Classified by Percent Time Computers Used for Word Processing (middle categories omitted) Low % Use	High % Use	Correlation Between Outcome and Percent Time for Word Proc.
High Schools:			
Learning in school subjects by above-average students	3%	12%	r=.19
Learning in school subjects by average students	1%	13%	r=.20
Special opportunities for the learning disabled	22%	26%	r=.15
Students helping other students with their questions	12%	39%	r=.26
Middle Schools:			
Learning in school subjects by above-average students	8%	12%	r=.16
Learning in school subjects by below-average students	17%	29%	r=.16
Special opportunities for the learning disabled	31%	51%	r=.16
Students helping other students with their questions	12%	33%	r=.15
Students working successfully on their own without supervision	12%	34%	r=.19

* Percentages shown are based on "much improved" responses from EITHER principal or PCUT with at least partial agreement from the other.)

In general, the outcomes that varied the most according to allocations of computer time were perceptions about student peer helping and perceptions about student learning in "regular school subjects." At the elementary school level, peer helping was modestly associated with emphasizing discovery learning and problem-solving activities. (See Table 4.) In fact, peer helping was the only outcome studied that was perceived more frequently in schools emphasizing discovery learning and problem-solving than in other schools at the same level.

The use of computer-assisted instruction, on the other hand, was slightly negatively related to perceived impact on peer helping, at least at the elementary level (r=-.12, see Table 5). However, schools that emphasized C.A.I. did report outcomes that other schools did not. At all levels, they were more likely than other schools to report that computers had improved the use of diagnostic tools and improved academic learning by below-average students (r's between r=.13 and r=.19) and had improved learning by average students at the middle school level (r=.17).

Table 4. Significant Relationships between Allocation of Computer Time to DISCOVERY LEARNING and Perceived Outcomes of Using Computers**

SCHOOL LEVEL AND OUTCOME	OUTCOME "MUCH IMPROVED" BECAUSE OF COMPUTERS (%) Schools Classified by Percent Time Computers Used for Discovery Learning (middle categories omitted) Low % Use	High % Use	Correlation Between Outcome and Percent Time for Discovery Lng.
Elementary (K-6) Schools:			
Students helping other students with their questions.....	16%	23%	r=.12
Diagnoses of students' learning problems or misunderstandings.....	31%*	10%*	r=-.18

* percent "much improved" or "improved"
** see note to Table 3.

Allocation of computer time for programming and computer literacy was negatively correlated with perceived learning outcomes at all three school levels. (See Table 6.) This was expected because the questionnaire explicitly asked about learning in "regular school subjects," and most respondents excluded "computers" from what they considered to be regular subjects. Nevertheless, schools that emphasized computer time for programming and computer literacy were also less likely to report improvements in other outcomes, such as peer helping, independence, or opportunities for gifted students. Table 6, for instance, shows that improved peer helping was reported slightly less frequently at middle and high schools emphasizing programming and literacy than at schools where teaching about computers was a small portion of instructional computer time.

Table 5: Significant Relationships between Allocation of Computer Time to COMPUTER-ASSISTED INSTRUCTION and Perceived Outcomes of Using Computers**

SCHOOL LEVEL AND OUTCOME	OUTCOME "MUCH IMPROVED" BECAUSE OF COMPUTERS (%) Schools Classified by Percent Time Computers Used for C.A.I. (middle categories omitted) Low % Use	High % Use	Correlation Between Outcome and Percent Time for C.A.I.
Elementary (K-6) Schools:			
Learning in school subjects by below-average students.....	10%	19%	r=.15
Diagnoses of students' learning problems or misunderstandings.....	11%*	32%*	r=.19
Students helping other students with their questions.....	24%	11%	r=-.12
Middle Schools:			
Learning in school subjects by average students.....	6%	12%	r=.17
Learning in school subjects by below-average students.....	14%	28%	r=.13
Diagnoses of students' learning problems or misunderstandings.....	21%*	42%*	r=.18
High Schools:			
Learning in school subjects by below-average students.....	6%	16%	r=.15
Diagnoses of students' learning problems or misunderstandings.....	13%*	32%*	r=.13

* percent "much improved" or "improved"
** see note to Table 3.

Table 6: Illustrative Relationships between Allocation of Computer Time to PROGRAMMING ACTIVITIES and Perceived Outcomes of Using Computers*

SCHOOL LEVEL AND OUTCOME	OUTCOME "MUCH IMPROVED" BECAUSE OF COMPUTERS (%) Schools Classified by Percent Time Computers Used for Programming (middle categories omitted) Low % Use	High % Use	Correlation Between Outcome and Percent Time for Programming
Middle Schools:			
Special opportunities for the learning disabled.....	42%	27%	r=-.17
Special opportunities for the academically gifted.....	27%	40%	r=.01
Students helping other students with their questions.....	23%	13%	r=-.02
Students working successfully on their own without supervision.....	21%	16%	r=-.03
High Schools:			
Special opportunities for the learning disabled.....	31%	26%	r=-.13
Special opportunities for the academically gifted.....	26%	22%	r=-.02
Students helping other students with their questions.....	34%	22%	r=-.12
Students working successfully on their own without supervision.....	34%	19%	r=-.16

* see note to Table 3.

Other Outcomes Suggested by Teachers

Besides asking PCUTs and principals to respond to specific ways that computer use might have affected learning and instruction at their school, we also asked PCUTs to write in their own words "another aspect of learning or instruction or one group of students that seems to have been particularly affected by using computers." Teachers answered differently -- some named particular categories of students, others indicated courses and subjects that were most affected, and still others identified skills and traits which they saw students developing through their computer activities. Some answers essentially repeated aspects of instruction about which we had already asked; others were quite different.

Six types of benefits were named most often (listed in order of decreasing frequency): (1) help with logic, reasoning, and problem-solving competence; (2) help for students with particular learning handicaps -- learning disabilities, Chapter I low-income backgrounds, limited-English-speaking minorities; (3) help for other below-average students needing remediation; (4) value for students in gifted and talented programs and other advanced students; (5) value for mathematics subjects and classes; and (6) improvement in self-confidence, a sense of accomplishment, and mastery over computer anxiety. Because the possible answers were so numerous, few respondents (less than 10%) gave any one answer.

Other relatively common answers concerned improvements in discipline, classroom climate, or classroom management and general skills like following directions or listening. Somewhat fewer respondents (again, in order of decreasing frequency) reported benefits for the following types of students, subjects, or skills: drill and reinforcement activities, English or reading, writing quality, social interaction or cooperation, "above-average" students (as distinct from honors or gifted students), initiative or creativity, word processing, computer programming classes, and computer literacy classes.

Also instructive are the kinds of answers which only a few teachers gave: boys, average students, computer buffs, vocational students, foreign language classes, social studies classes, career choices, and factual knowledge.

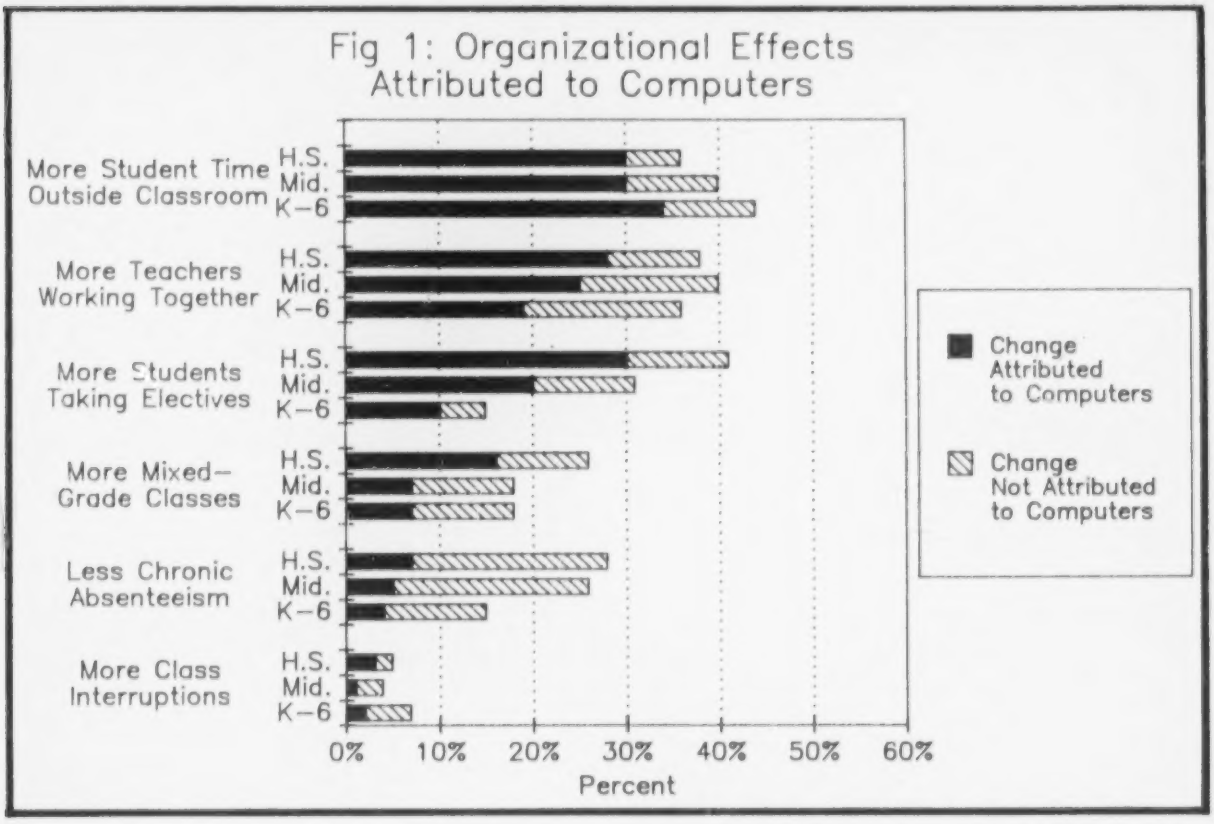
Organizational Outcomes: Principal Reports

Besides affecting students directly, computers might be changing how school instruction is organized. To assess this, we asked school principals with at least two years tenure at their current school about several aspects of school organization: the proportion of time that students spent in non-classroom instructional settings, such as labs and resource rooms; the assignment of students from different grade levels to the same classes; the provision of elective classes; teacher collaboration across grade levels or departments; absenteeism; and the frequency of classroom interruptions. The principals were asked how these aspects of school organization had changed in the past three years and whether the use of computers was related to the changes that they saw.

At all three levels, elementary, middle, and high school, only a minority of principals believed that these aspects of school organization had changed in their building. For three of the six areas, however, a majority of principals who DID report changes believed that computers were related to the change.

The organizational change most often experienced and the one most often attributed to computers was an increase in the time that students spent "away from regular classrooms -- in libraries, labs, resource rooms." At the elementary level, 44% of principals reported an increase in non-classroom activities, and, of that 44%, 78% believed that computers were related to this increase. Thus, 34% (i.e., .44 x .78) of elementary schools reported increased out-of-classroom activity because of computers. (See Figure 1.) Nearly the same proportion of middle schools and high schools also reported this effect.

Two other effects of computers were reported by a substantial number of principals at computer-using middle and high schools: an increased number of electives and an increased frequency of teachers from different departments working together on joint projects. Again, although a minority of principals (30 to 40 percent) reported these changes, most who did felt that computers were at least partly responsible (63% to 75%, depending on school level and the item). A smaller proportion of



elementary school principals reported these two changes, but most of those who did attributed the changes to computers.

Fewer than 10% of principals at computer-using schools believed that computers affected the other three aspects of organization asked about. Computers were seen as increasing the frequency of mixed-grade classes in 16% of high schools, but only 7% below that level. Only 5% of the principals saw computers as a factor in decreasing absenteeism, and only a few believed them to be responsible for increasing classroom interruptions.

Other School-Level Changes

In our questions to computer-using **teachers**, we asked how their school's use of computers had changed over the past year. We asked about changes in the amount of use (days of non-use and incidence of waiting lines or sign-up sheets), teacher involvement (how often teachers borrowed computers for use at home), and recreational use (students playing arcade games and copying commercial software). Their answers extend our understanding of the increased use of computers suggested by the statistics on time-of-use, described in issue 1 of this newsletter series.

Nearly half of the schools reported that their computers sat idle for fewer days than they had a year earlier, and nearly 40% reported that there were more days on which students either stood in line or signed up in advance to use school computers. (See Table 7.) Few schools reported changes in the opposite direction. Additionally, one-third of the schools reported increased borrowing of computers by teachers for use at home.

In contrast, recreational use of school computers seems, on balance, to have decreased. Schools were more likely to indicate a decline in students' arcade game playing than to indicate an increase. And, below the high school level, most schools said that students did not use school computers to copy commercial software. Still, with the increasing activity at school computers, it was not surprising that more schools suggested that copying was increasing at their school than said it was decreasing. (See Table 7.)

Table 7: Perceived Changes in Certain Aspects of Computer Use

	Changes Compared to One Year Earlier			
	More Often	No Change	Less Often	(Never Any)*
Days when computer is not used.....	5%	17%	47%	31%
Queuing (waiting lines or sign-up sheets).....	38%	30%	11%	21%
Teachers borrowing computer for home instruction or use	31%	32%	6%	32%
Arcade game playing.....	13%	24%	21%	42%
Students copying commercial software.....	12%	17%	5%	66%
K-6 Elementary schools.	6%	10%	2%	82%
Middle schools.....	21	18	8	53
High schools.....	19	32	12	37

* "Never Any" of that type of use of computers.

A belief that computers were responsible for improved student learning and a better academic climate was most prevalent at schools reporting increased computer activity -- where there was more queuing for computers, less idle time, and more frequent borrowing of school computers by teachers. The student outcomes most related to increased computer activity were student enthusiasm (at all school levels), and peer helping, independent work, and individualized assignments (in the elementary grades). For example, of the elementary schools that reported having a declining number of days where computers were idle (or no idle days at all), 38% indicated that computers had caused "much more" enthusiasm for school subjects. But only 12% of elementary schools where idle days were stable or increasing reported that computers had had that kind of an effect.

Middle schools that reported increased queuing for computers also perceived computers to have a stronger effect on peer cooperation, independent student activity, and individualized assignments than those reporting declines in queuing. For example, 22% of middle schools that reported increased queuing for computers said that there was a much greater incidence of students working without direct supervision (as a result of computers). Only 7% of middle schools that said there was never any queuing for computers indicated such an effect. High schools where an increasing number of teachers borrowed computers were more likely to report better outcomes associated with low-performing students, and high schools increasingly beset with lines and sign-up sheets for computer use reported better learning outcomes for all types of students.

Of course, the causal forces work in both directions. For example, student enthusiasm probably causes less idle computer time and more queuing, but increased computer use may also generate more enthusiasm as well. Similar issues of directionality remain for the other associations discussed above.

Recreational use of computers had only a limited impact on the student outcomes measured. Below the high school level, schools with an increasing or stable use of computers for playing arcade games reported outcomes no different from schools that said that arcade game activity was declining or non-existent. At the high school level, there were a few small relationships. The largest was that high schools reporting increased game playing were less likely than other schools to indicate that computers had resulted in "more learning" by average students (24% vs. 43%). Increased student copying of computer programs was not associated with any of the outcomes examined, except for a slight relationship at the high school level between increased copying and computers having less of an impact on learning by average students.

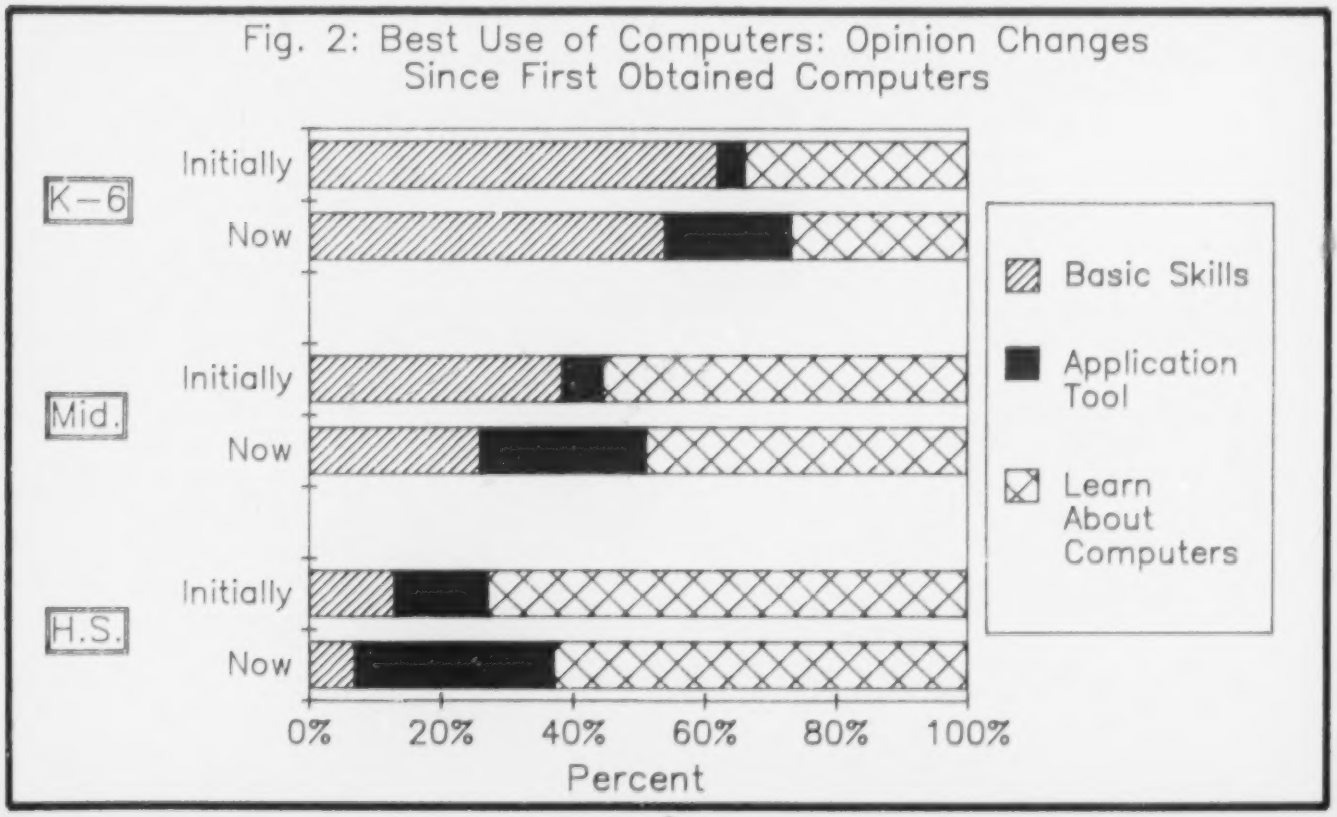
One-half of the schools that had used computers for two years or more reported an increase in the number of students who could "touch type," and one-third of the schools with computers for two years reported offering typing or keyboarding instruction to students at lower grade levels than previously. A similar proportion of schools at all levels -- elementary, middle, and high school -- reported these increases.

Basic Skills Teaching, Object of Instruction, or Applications Tool?

One goal of this survey was to see whether, over time, schools were changing their views about the best way to use computers. We asked the primary computer-using teachers which one of three major uses of computers seemed best at the time their school got its first computer and which one seemed best now (in 1985). The three approaches were (1) using computers as a method of improving students' basic skills in mathematics or language, (2) using computers as a resource to learn more about computers, and (3) using computers as a tool for students to accomplish an academic task -- such as in writing, analyzing data, or solving problems. We analyzed these questions only for schools that were into at least their third year of having computers and where the primary computer-using teacher was at least familiar with the school at the time it began getting computers. Figure 2 summarizes the results of this analysis.

Elementary and secondary schools had quite different views about the best way to use computers. Not surprisingly, the differences paralleled differences in how computers were actually being used at the two levels. A majority of K-6 school PCUTs with two or more years of computer experience believed that the best use of computers at their level was applying them to students' mastery of basic reading and math skills. Middle and high school PCUTs believed that the best use of computers at their level was mainly for students to develop computer-related skills such as programming. "Learning about computers" was the choice of one-half of the PCUTs at middle schools and nearly two-thirds of the PCUTs at high schools with two years of computer experience.

However, when we look at how the responses to the question about "current best use" differ from those given for "use thought best at first," we see similar changes in opinion



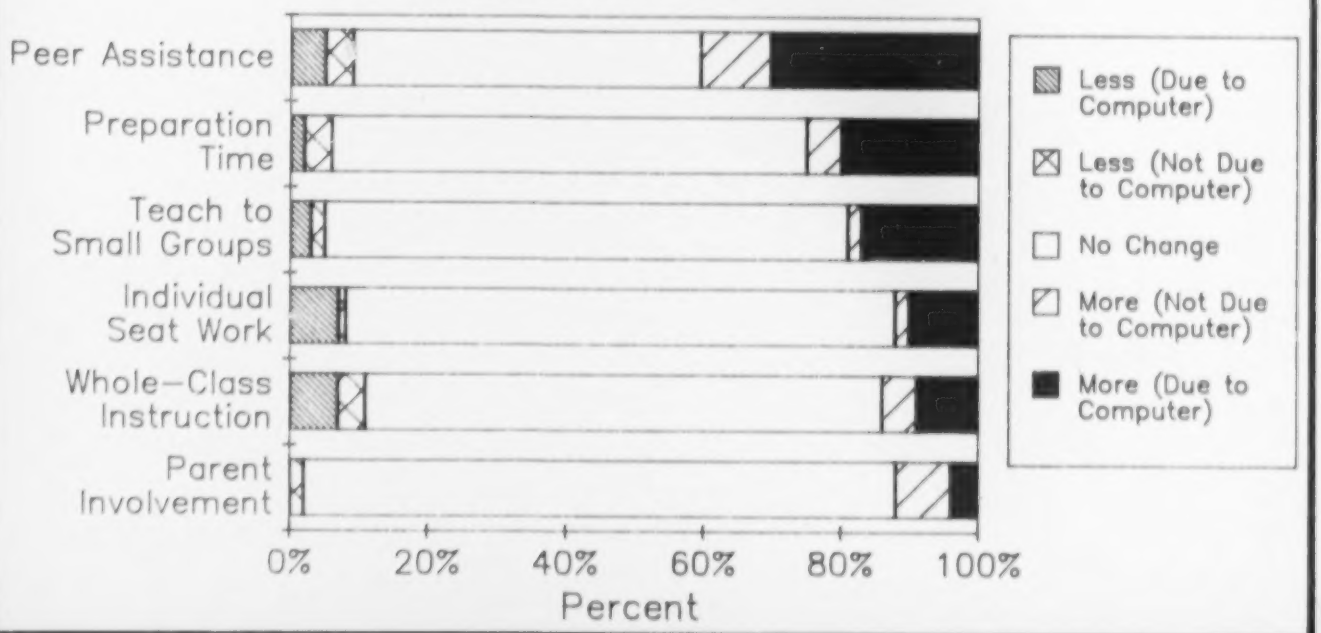
occurring in both elementary and secondary schools. An increasing proportion of elementary, middle, and high school PCUTs were coming to believe that the best way to use computers at their school was as a tool to help students accomplish concrete tasks -- tasks in writing, problem-solving, data analysis, and perhaps other areas. A similar change in emphasis was occurring during this period in the professional literature on educational computing. Favoring "tool uses" was still a minority viewpoint among educators in 1985, but it was becoming more significant. It would be instructive to learn whether it has become the dominant preference among PCUTs today.

Changes in Teaching Methods

The results discussed so far are generalizations made by school principals and primary computer-using teachers about the computer's impact on the school as a whole. The remaining survey results derive from individual computer-using teachers about how computers have affected their own teaching practice. We asked teachers to tell us about changes in their teaching methods since they began using computers -- changes that might be attributable to their use of computers. We named six possible effects: changes in (1) how frequently they divided their class into groups for instruction and other activities, (2) how often they assigned individual seatwork, (3) how frequently they used whole-class lecture or discussion methods, (4) how often students were instructed to tutor or help one another, (5) how much they worked evenings and weekends preparing to teach, and (6) how often the teachers talked with students' parents (an expected "non-effect" that served as a baseline comparison). We asked teachers to discuss each of these possible changes for one particular class or subject they taught -- the first class or subject taught during the day for which computers were sometimes used. We excluded teachers who wrote about subjects that could not be adequately taught without computers such as "computer literacy" or "computer programming" courses.

The vast majority of teachers reported that their style of organizing classroom instruction and how much time they put into class preparation had not changed since they began using computers. Still, some changes attributed to computers were reported much more often than others. Figure 3 shows the proportion of computer-using teachers of grade 6-8 classes who indicated an increase, a decrease, or no change, in each aspect of instruction for the sampled

Fig. 3: Changes in Teaching Practices Since Began Using Computers for Subject -- Grade 6 to 8 Classrooms



subject. The proportion attributing such changes to computers is indicated by darker patterns than those indicating the changes were not computer-related. Although Figure 3 displays data for the middle grades only, the changes in instructional practice most often attributed to computers were about the same at all levels.

High school teachers reported more changes than middle-school teachers, and middle-school teachers more than elementary school teachers. Also, the higher the grade-level taught, the more likely that a reported change was attributed to "computers." For example, at the elementary school level, 59% of the reports of changed instructional practice were attributed to computers, compared to 70% at the middle school level and 79% at the high school level.

The largest reported impact of computers on instructional practices was on mutual helping among students. Roughly 40% of computer-using teachers indicated that they increasingly used peer-tutoring and helping -- somewhat more at higher grades and somewhat less below grade six. Of the computer-using teachers who reported increased use of peer helping, more than three-quarters said that their use of computers was at least partly responsible.

Increases in class preparation time were reported by 25% of the middle grade computer-using teachers and by 37% of the high school teachers. Well over 80% of the teachers reporting increased preparation time said that computers were responsible.

There were fewer changes reported for whole-class instruction, instruction in small groups, and seatwork than for peer-helping and preparation time. Averaging for these three types of classroom organization, changes were reported by 28% of high school computer-using teachers, 23% of teachers of the middle grades and 18% of K-5 teachers. The most common change was an increase in grouping -- dividing the class into work groups and teaching one group while another used available computers and others did seatwork or group work. Also, increases in seatwork assignments were reported somewhat more often than decreases, particularly at the high school level. Changes in grouping and seatwork practices were attributed to computers by 80% of the teachers reporting such changes, but only a slight majority of those indicating a change in whole-class instruction also attributed this to computers.

As expected, the least change reported was for "talking with parents." Only 10% reported increases in this area (and 2%, deceases), and fewer than one-third of those reporting changes attributed them to the use of computers.

Teachers of some types of classes reported more changes in teaching practice than others did. Below the high school level, computers caused increased preparation time and peer helping practices mainly in classes with high ability students. (See Table 8.) For example, among elementary grade computer-using classes, 26% of the teachers of low- and mixed-ability classes reported increased peer-tutoring and peer-helping practices, but nearly twice as many, 48%, of the teachers of high-ability K-5 classes reported these effects. Comparable results obtained at the middle grades. Similarly, one-fifth of middle school teachers of low- and mixed-ability classes and even fewer elementary teachers of low- and mixed-ability classes said that the time they devoted to class preparation had increased because of computers, but roughly one-third of high-ability class teachers in these grades reported spending more time on class preparation because of computers.

Table 8: Changes in Classroom Teaching Practices by Class Ability Level*

	K-5 Grade Classes			6-8 Grade Classes		
Changes in Practice	High Ability	Average & Mixed	Low Ability	High Ability	Average & Mixed	Low Ability
Increased Use of Peer Tutoring, Helping	48%	26%	26%	45%	32%	21%
Increased Evening, Weekend Preparation	30%	10%	15%	33%	19%	22%
Increased Within-Class Grouping	11%	8%	19%	11%	16%	19%
Increased Use of Seatwork	9%	8%	8%	10%	10%	12%
Decreased Whole-Class Instruction	1%	4%	9%	9%	3%	15%

* Excludes classes about computers ("literacy" and "programming") that would not have been taught WITHOUT computers.

Some computer-related changes in classroom organizational structure were more often reported by elementary and middle grade teachers of low-ability classes than by teachers of mixed- or high-ability classes. Twice as many teachers of low-ability classes in these grades reported increased use of grouping for

instruction and decreased whole-class instruction than did teachers of mixed- or high-ability classes. Still, compared to the effects of computers on peer-group and preparation time, relatively few teachers of any ability levels reported these organizational effects.

High school teachers reported a very different pattern of effects. Teachers of high- and low-ability classes were less likely to see an impact of computers on their teaching practice than were teachers of average- and mixed-ability classes. This is probably related to the subjects for which classes of different ability levels used computers. High school math and science teachers primarily used computers with high-ability math and science classes and low-ability math classes, and math and science teachers were the least likely to report changes in teaching practice because of computers. Average- and mixed-ability computer-using classes are exemplified by business and English classes, where teachers were the most likely to report that using computers had changed their teaching practices.

Half of the high school business computer-using teachers said that computers had increased their practice of asking students to help one another, but only 20% of high school computer-using math and science teachers said this. (See Table 9.) Similarly, business teachers were more than twice as likely as math or science teachers to indicate that computers had increased their use of grouping for instruction (24% vs. 11%), increased their frequency of assigning seatwork (28% vs. 9%), or decreased their use of whole-class instruction (21% vs. 7%). Almost as many computer-using high school English teachers reported that computers had affected their teaching practice as did business-education teachers. For example, 46% said that computers had increased their use of peer tutoring in English classes, and 26% said that they assigned more individual seatwork because of computers.

The effects of these teaching practices on student learning are not easy to predict. Most educators would agree that seatwork has rapidly declining marginal value for individual students, but it does contribute to more efficient classroom management. Instructing students in small groups may have particular value in heterogeneous classes or where subject-matter learning is highly cumulative, but its overall effectiveness depends on how well activities are organized for times when the teacher's attention is elsewhere. At its worst, group activity can degenerate into recreational time and makes classroom management more difficult. Whole-class instruction is most effective in teaching less complex skills and concepts, especially to homogeneous classes, where a common instructional pace is functional for most students. Even the value of having students tutor and help one another may depend upon the way roles, tasks, and incentives are organized and the subject-matter and student body involved. There is no guarantee that slower or less motivated students will learn more from group activity than from teacher-centered whole-class instruction. We cannot simply assume that, because many teachers report

Table 9: Changes in High School Teaching Practices by Subject*

Changes in Practice	Business Classes	English Classes	Science Classes	Math Classes	Other Classes
Increased Use of Peer Tutoring, Helping	50%	46%	21%	19%	34%
Increased Evening, Weekend Preparation	45%	24%	24%	25%	36%
Increased Within-Class Grouping	24%	22%	10%	12%	18%
Increased Use of Seatwork	28%	26%	8%	10%	15%
Decreased Whole-Class Instruction	21%	22%	5%	8%	5%

* Excludes classes about computers ("literacy" and "programming") that would not have been taught WITHOUT computers.

increased peer helping as a result of computer use, resulting student mastery is uniformly better.

In any event, computers seem to have had limited effects on the organization of classroom instruction to date. Increased peer helping is about the only way that computers have affected major classroom teaching processes. Otherwise, computers have not substantially affected how teachers teach their material or run their classes. The one thing they have done, of course, is to make teachers work harder and longer preparing for their classes. Whether this is simply a short-term consequence of changing classroom activity patterns, or whether it is a long-term concomitant, we cannot say.

What Did Teachers Report That Students Learned "Better, Faster, or More Thoroughly" Because of Computers?

Besides asking computer-using teachers about how computers affected their teaching practice in one particular class, we also asked for their opinion about how computers might have affected student learning in that class. The question was put in an "open-ended" format so that teachers were free to name anything they felt that students had "learned better, faster, or more thoroughly because of their use of computers in this subject?"

The teachers' responses generally reflected the subject for which they used computers. In mathematics, a majority of teachers named "math facts" as a way that students' learning had been affected by their use of computers. Most often, specific improvements that they mentioned related to computational speed or automaticity. Far fewer teachers indicated improvements in comprehending or applying mathematics concepts.

The responses of K-5 English and reading teachers were about equally split among reading comprehension, vocabulary, grammar, and spelling; fewer teachers at this level mentioned improvements in writing or editing skills. However, writing improvements were among the most important outcomes perceived by English teachers of older students. In the middle grades, writing improvements were mentioned as often as improvements in grammatical usage (21% of the teachers) and more often than spelling, reading comprehension, or vocabulary. Among high school English teachers using computers, fully 69% indicated that students had improved their writing, editing or proofreading skill by using computers -- a greater consensus than for any other "effect" for any subject at any grade level. In addition, more business education teachers indicated improvements in student writing than indicated any other learning effect (21%). Overall, 19% of all high school computer-using teachers suggested that improved writing was an important outcome of their use of computers, a higher percentage than those naming any other outcome. Of course, it should be recalled that teachers of classes ABOUT computers (programming and computer literacy classes) did not answer this question, because it was part of the series of questions about how teaching practice in the subject had changed since the teacher began using computers.

Improvements in math, spelling, reading, and vocabulary were noted generally more often by teachers of low-ability classes than by teachers of mixed- or high-ability classes. (The percentages for those four subjects combined were 66% of low-ability classes, 43% of mixed-, and 26% of high-ability classes.) More teachers of high-ability classes than low- or mixed-ability classes volunteered that students' logic, critical thinking, and problem-solving skills had improved through the use of computers (20% vs. 8% and 11% respectively). Also, keyboarding and typing skills were named as having been improved more often in high-ability classes than in low- and mixed-ability classes (12% vs. 4%).

Overall, the answers to this question about "things learned better, faster, or more thoroughly" reinforces the idea that computers have been more effective in high- and low-ability classes than in average or mixed-ability classes. Teachers of mixed-ability classes were more likely to simply answer the question of what things have students learned "better, faster, or more thoroughly" by saying "none." One-third of teachers of mixed- or average-ability classes said "none" compared to 16% of teachers of low-ability classes and 20% of teachers of high-ability classes. Actually, we were surprised that this many computer-using teachers gave the "none" response. Nearly any response the teachers wrote in would have been coded as indicating some improvement due to computers. The fact that more than one-quarter of the teachers wrote "none" suggests that,

regardless of how much more enjoyment computers might add to the learning process, many computer-using teachers were not impressed with the computer's contribution to improving students' academic performance.

Moreover, rather than naming achievement outcomes as things students "learned better, faster, or more thoroughly," some teachers named behavioral or attitudinal outcomes. The ones most frequently named were "following directions" (6%), "social and helping skills" (3%), "motivation" (3%), and "independence and self-esteem" (3%). "Following directions" was named as an outcome more in low-ability elementary and middle-grade classes than elsewhere. "Social and helping skills" were more often mentioned by high school English teachers. And "motivation" was named more often by high school math and science teachers. (Each was named by about 8% to 10% of those types of teachers.)

Summary of Perceived Effects

The opinions of computer-using teachers and principals about changes in computer use and the impact of computers very much echo the more "objective" data about patterns of computer use that we reported in the first two issues of this newsletter. Together, our analyses indicate that schools are becoming serious about trying to use computers to reach important learning objectives. They report substantially greater use (e.g, more competition for computer time, fewer days idle, more teacher borrowing); more activity directed to accomplish an academic goal (e.g., less game playing); increased interest in having students using computers as a tool for improving their intellectual productivity (e.g., increased word processing use); some restructuring of arrangements for supervising students (e.g., greater use of laboratory and library settings for learning); increased cooperation among teachers and a greater investment in teacher preparation time (particularly for high-ability classes and in high school).

The most pervasive perception among teachers is that computers have improved the climate for learning by increasing student motivation in subjects for which they use computers. They are less willing to cite actual improvement in student learning generally, but they see several specific areas of improvement -- students helping one another, particularly in high-ability classes using discovery learning and problem-solving software and in high school classes involving writing; students working independently without close adult supervision; below-average and learning-disabled students improving their computational skills in mathematics by means of computer-assisted instruction; and high-ability students exercising their reasoning and thinking skills. They see the computer as having brought benefits primarily to high-ability students at all levels and to low-ability elementary and middle-grade students, although the benefits seen are primarily described as "opportunities to learn" rather than concrete achievements. Learning outcomes are viewed most positively in schools emphasizing word-processing activities, and nearly all outcomes are significantly stronger in schools with better computer-to-student ratios.

Evidence of Effectiveness

How accurate are those perceptions? Have instructional programs using computers accomplished as much as participating teachers and principals believe -- or have they helped even more than the participants recognize? As social scientists, we understand that participants in a social system do not always have the distance and breadth of experience required to know the consequences of their activities. The perspectives of school-based educators are vitally important to understand the role that computers are playing in school classrooms today. But we need additional evidence.

First, because most methods of instruction teach most students some things, we should consciously use the word "effective" to mean learning in comparison to other methods or programs of instruction. Thus, we should ask whether using computers in a particular setting enables those students to learn better and learn faster and to learn with less cost in personnel, materials, and equipment than if the same instruction were provided in other ways. Also, we must consider that teaching students certain skills by computer may take time away from their learning other skills. Thus, an appropriate evaluation of computer-based instruction must take into account the value of the skills or content learned by computer in comparison to

the "opportunity cost" of skills and content not learned.

We need to develop or use appropriate tests that measure how well students have mastered the learning objectives that we set out for them -- or other capacities that may have developed serendipitously in the process of using computer programs. These tests might be standardized achievement tests if the instructional objectives match fairly well the content of such tests. But in many cases, we must develop tests from scratch, based on concrete curriculum objectives covering a variety of factual, integrative, and analytic learning. We should measure the appropriate skills both before and after the learning experience so that we can identify learning actually due to the experience itself rather than learning that was previously acquired.

We cannot depend only upon the judgments of observers or participants to know the relative effectiveness of computers compared to alternative methods, especially for diverse populations of students with varying academic backgrounds, learning styles, and abilities. One program of instruction may produce some outstanding accomplishments by some students, and it may be regarded as evidence of the value of that approach. Had another instructional approach been used, a different pattern of accomplishments, perhaps equally valuable, may have resulted. Without comparing across instructional methods and considering the achievements of ALL students in a class, we are at best gaining only partial knowledge of the impact of an instructional approach.

Thus, we need to measure student accomplishments not only among students using computers, but also among students receiving alternative methods of instruction with the same educational objectives. To be most helpful, the evaluation should be conducted in settings employing planned experimental designs so that biases associated with self-selection do not artificially color our conclusions. For example, if the more instructionally effective teachers choose to use computer-based instructional programs, greater student achievement in those classes may be teacher effects, not the effects of the computer-based instruction.

We need to take these measurements under varying conditions in order to learn the limits within which our conclusions about instructional effectiveness hold. Do they hold only for classes of high-ability students or for classes of low-ability students? Do they appear only when heterogeneous classes are taught using certain methods adapted to the varying needs of their students? Do they hold only when the student-to-computer ratio within a classroom is at least 2-1, or 4-1, or 8-1? Do they hold only for classes of teachers of exceptional ability or only for teachers enthusiastic about using computers, or do computer-based methods mainly improve the teaching effectiveness of teachers who are "just adequate"?

Needed Research

The results reported here -- outcomes of using computers perceived by teachers and principals -- are essentially hypotheses about the conditions under which various aspects of effectiveness hold. They await empirical verification using well-designed field studies and appropriate measures of student accomplishment.

It is time for school systems that have used computers for several years to organize or participate in well-designed evaluations to measure the relative effectiveness of computer-based approaches to instruction. Such evaluations should employ experimental designs -- that is, both "computer" and "non-computer" approaches to teaching the same material, random assignment of students or classes to these alternative treatments, and post-tests equally appropriate to the instruction given by each method. Many schools now have enough experience in using computers for certain subjects and grade levels to be excellent sites for such studies.

In the next several years, we plan to bring together schools and school districts willing to conduct such evaluations into a cooperative research activity -- the **National Field Studies of the Effectiveness of Instructional Uses of School Computers**. Our work will focus on five distinct subject-areas at the upper-elementary and middle-school levels: computer-assisted instruction in mathematics, writing, earth science, reasoning and problem-solving skills, and social studies. Schools and districts interested in participating in these studies are welcome to write to us for further information.

Newsletter Issues 4 - 6

Because of the importance of computers in mathematics and science education, we decided to devote an entire issue to that topic, thus postponing it until the next issue (Issue 4). Subsequently, issue 5 will focus on computer programming and computer literacy, and issue 6 will discuss writing, language arts, social studies, and vocational applications. Roughly, two months of work go into the preparation of each issue, so expect the series to conclude about April.

Subscription Information

The complete series of six newsletters is available by subscription for $7.50, payable to The Johns Hopkins University. Write to Computer Survey Newsletters, Center for Social Organization of Schools, Johns Hopkins University, 3505 N. Charles St., Baltimore, MD 21218.

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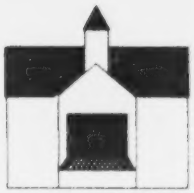
Instructional Uses of School Computers



Reports from the 1985 National Survey Issue No. 4, June 1987

Center for Social Organization of Schools The Johns Hopkins University

Henry Jay Becker, Project Director

In previous issues of this newsletter, we presented basic information about the ways schools use computers, the opportunities different types of students have to use them, and the consequences teachers and principals see from their use. In this and the next two issues, we will present more detailed data about how computers are used in specific areas of the school curriculum. In this issue we focus on traditional topics in science and mathematics education including arithmetic, algebra, geometry, higher math, biology, physics, chemistry, and general science. In the next issue, we will include coverage of less traditional mathematics areas including logic, Logo, and general problem-solving and discuss "computer literacy" and computer programming instruction.

Apart from Arithmetic Drills, Very Little School Computer Use is For Mathematics and Science Instruction

From the earliest attempts to use electronic computers for school-based instruction to the present, arithmetic drills and limited tutorial instruction in arithmetic have been among the most common computer activities in schools. Despite the concentration of mathematics applications in the early grades, in the secondary grades only a very small portion of instructional activity with school computers has been devoted to traditional mathematics subject-matter. Science subject-matter has constituted a similarly small part of school computer use, at both elementary and secondary levels. These conclusions may startle some readers because of the commonly held association between computers and mathematical and scientific pursuits. But these conclusions become inescapable from examining the facts about computer use in schools shown in Table 1.

Table 1 shows the distribution of instructional computer time in U.S. schools in Spring, 1985 at five grade-level ranges: K-2, 3-5, 6-8, 9-10, and 11-12. Percentages of total computer use at those levels are shown for groups of mathematics subjects, for science, for related "computer" subjects, and for all other subjects. By "subject" we mean the instructional topic or manifest content of the computer programs used by the students. So, for example, programming in a mathematics class was classified as programming use if the instructional topic reported for the activity was described in terms of computer programming competencies; it was classified as mathematics if the topic reported was a mathematics skill. Participating teachers reported on one sample instance of computer use in one class or subject. Each report was weighted by the frequency that computers were used in that class or subject and by the number of classes or subjects for which the teacher used computers. (The results in Table 1 differ somewhat from similar data presented in Issue 2 of this newsletter because of refinements in these measures.)

The proportion of computer time devoted to mathematics instruction is shown in the top part of Table 1. For example, 38% of the computer time used by kindergarten through second-grade students was spent on arithmetic-related activities. In contrast, algebra and geometry -- typically taught to 9th and 10th grade students -- occupied only 2% of the computer time in all

ninth- and tenth-grade computer-using classes. Moreover, through the 10th grade, there was vastly more use of computers for basic mathematics (remedial instruction, applications of basic computations in "word problems," etc.) than in the more advanced mathematics topics. Use for understanding and practice in algebra, geometry, trigonometry, and advanced mathematics altogether constituted roughly 3% of the computer time at both the middle school and high school levels while general math instruction occupied 24% of middle school computer use and roughly 7% of high school use (13% in grades 9-10 and 3% in grades 11-12).

Looking at the mathematics data in Table 1 from another perspective, more than one-quarter of all mathematics taught by means of computers was taught to children in the 2nd grade and below, and 63% of the use of computers for mathematics occurred in grades 5 and below. Only 8% of the use of computers for strictly mathematics topics (from remedial arithmetic through calculus and statistics) occurred in the high school grades.

In science classes, computer use occupied about 5% of the instructional time on computers in high school, roughly 3% in the middle grades, and only 1% in the elementary grades. At no grade level did science instruction using computers comprise as much as 10% of that grade's overall use of computers. The proportion of computer use going to science instruction was at its maximum in grades 9 to 10 and fell off sharply (to 3 or 4%) in the grades immediately above and below that range.

Yet Many Math and Science Teachers Use Computers for Instruction

This is not to say that few science and mathematics teachers were using or teaching with school computers. In middle and secondary schools, about 20,000 teachers of science courses and 56,000 teachers of math courses made some use of computers in those subjects during the 1984-85 school year. These teachers constitute roughly one-sixth of the science teachers and one-third of the math teachers in the middle and high schoools.

Table 1: Proportion of Instructional Computer Use(1) for Mathematics, Science, and Computer Subjects by Grade Level, Spring, 1985.

INSTRUCTIONAL FOCUS OF USE	GRADE LEVELS OF COMPUTER-USING CLASSES				
	K-2	3-5	6-8	9-10	11-12
Mathematics					
Whole number arithmetic(2)	38%	25%	8%	2%	1%
Intermediate mathematics(2) (decimals, fractions, and percents, and math applications for older students)	0%	12%	16%	11%	2%
Algebra & geometry(4)	0%	0%	2%	2%	1%
Advanced mathematics	0%	0%	1%	1%	1%
Sub-Total: traditional math instruction(3)	(38%)	(37%)	(26%)	(16%)	(5%)
Computer topics (largely related to math)					
Logic, logo, & problem-solving	2%	4%	7%	2%	0%
Computer literacy --unclear topics	8%	11%	7%	5%	5%
Computer programming(4)	3%	2%	19%	24%	51%
Sub-Total: computer topics	(13%)	(17%)	(33%)	(31%)	(51%)
Science (all subjects)	1%	1%	3%	9%	4%
Other subjects (language arts, writing, business, etc.)	48%	45%	38%	44%	35%
Total	100%	100%	100%	100%	100%

(1)Each computer-using class is weighted by the estimated time of total use.

(2)Unspecified mathematics (13% of all use) classed as whole number arithmetic (K-2); 67% arithmetic, 33% fractions, decimals, percents (3-5); 33% arithmetic, 67% fractions (6-8); 50% fractions, etc., 20% arithmetic, and 30% algebra (9-12).

(3)Of all traditional mathematics instruction using computers, 26% occurred at grades K-2; 47% at grades 3-5; 18% at grades 6-8; 5% at grades 9-10; and 3% at grades 11-12.

(4)Programming in a math class was classified as programming use if the topic reported for the activity was a programming topic and as mathematics if the topic reported was a math topic.

How can this be? How can so many secondary school mathematics and science teachers be using computers, but so little of the computer use be in mathematics and science? Three factors are at work here: the courses that mathematics and science teachers teach for which they use computers, the intensity that computers are used in these courses, and the particular instructional activities and focus of computer use in these courses.

Math and Science Teachers Use Computers Primarily to Teach ABOUT Computers

In addition to using computers for instruction in math and science per se, math and science teachers at the secondary level are heavily involved in teaching computer literacy and programming courses. If we consider all high school math and science teachers who used computers for at least one course they taught during 1984-85, and we then select at random one computer-using course for each of these teachers, we would find that about 10% of the science teachers' courses and fully one-half of the math teachers' courses involved using computers to teach programming or computer literacy and not math or science subject-matter.

Moreover, the programming and computer literacy classes tended to use computers more often than these same teachers' mathematics and science courses. So if we took a sample of OCCASIONS on which computers were used in courses taught by math and science teachers, nearly one-fourth of those taught by science teachers and nearly two-thirds of those taught by math teachers would have involved teaching programming or computer literacy. At the middle school level, the proportion of math and science teachers' instructional time on computers going to computer instruction is somewhat smaller but is still substantial (17%, science; 28%, mathematics).

Thus, above the level of arithmetic drills, the primary involvement of math and science teachers with computers (at least as of Spring, 1985) has been to use them as the object of instruction rather than as the means of providing traditional instruction in mathematics and science.

Intensity of Use by Type of Class

Secondary science and mathematics classes that used computers did not use them even as frequently as did computer-using classes in other traditional subjects -- in particular, business education, writing, basic mathematics and language arts. Figure 1 shows the proportion of different kinds of classes that (1) used computers in the 3 days prior to the survey, (2) used computers "every week" or "most weeks", and (3) used computers for at least 3 days out of every 10 during the year. Results are shown for math classes, science classes (except for the elementary level, where there were too few), computer classes, and other classes, with some of the mathematics and science categories divided into more specific subjects. "Classes" at the elementary level refers mainly to "subjects" -- not separate class periods as in secondary school.

In high school, among classes that used computers at all, both science classes and mathematics classes (algebra and above) used computers less intensively than did classes in other subjects. The computer-using teachers that, as a group, used computers LEAST intensively with their students were chemistry teachers, where only one-sixth of the computer-using classes used computers to the extent measured in Figure 1 (using an index that combines the three aspects of use shown in that figure). One-third of the biology classes and 44% of high school physics classes used computers to that extent.

Computer-using classes in algebra, geometry, trigonometry, and other advanced math subjects reported levels of intensity similar to those reported for science classes. For example, only 18% of the computer-using classes in high school mathematics (algebra and up) reported using computers "every week" or "most weeks," compared to nearly two-thirds of the computer-using classes outside of mathematics, science, and computer science.

At the middle school level (grades 6-8), fewer than one-fifth of the computer-using science classes used computers for at least 3 days out of every 10. More than half of middle grade mathematics classes that used computers at all used them that much. In classes outside

of math and science that used computers, nearly three-fourths used computers for 3 days out of 10.

In the elementary grades, the pattern was very different than in the higher grades. Computers in mathematics instruction were used on a more frequent basis than in other academic subjects. For example, two-thirds of the elementary math classes using computers used them "most weeks" or "every week" compared to just over half of the classes using computers for other subjects (other than "computer literacy"). We had only 14 elementary classes in our survey where computers were used for science instruction, and computers were used in these classes only occasionally.

Math and science computer-using teachers used computers relatively intensively in two general areas: (1) for basic and intermediate mathematics (below algebra) and (2) for classes and units in computer programming and computer literacy. At all levels, elementary through high school, teachers who used computers for these topics used them frequently. A majority of computer-using teachers of pre-algebra mathematics classes reported in 1985 that they used computers "every week" or "most weeks" for topics in whole-number arithmetic, fractions, decimals, or percents. These basic mathematics courses reported "intensity percentages" in the 50%-70% range from elementary through high school. In contrast, the more advanced math courses had percentages around 20% for the measures of frequency of use shown in Figure 1.

Not surprisingly, the courses with the highest reported intensity of computer use were computer-specific courses such as programming and computer literacy, taught mainly by math and science teachers. Their reported percentages were around 90% in high schools, 70% to 90% in middle schools, and 55% to 85% in elementary schools.

How Computers Were Used in Computer-Using Math and Science Classes

A third part of the explanation for the contrast between the large number of computer-using math and science teachers and the small proportion of computer time being devoted to science topics and mathematics topics (above arithmetic) has to do with the instructional activities occurring in computer-using math and science classes. A substantial fraction of both "math" and "science" computer activity in the middle grades is instruction where the computer skills are themselves the objective of instruction rather than the means of instruction (i.e., "computer literacy" as a math or science subject).

For example -- see Table 2 -- nearly one-fourth of all activity in computer-using science classes in secondary school is programming. So is 15% of the computer activity in middle school mathematics courses and 17% of the computer activity in high school math classes (algebra and up). Of course, not all programming instruction is for the purpose of

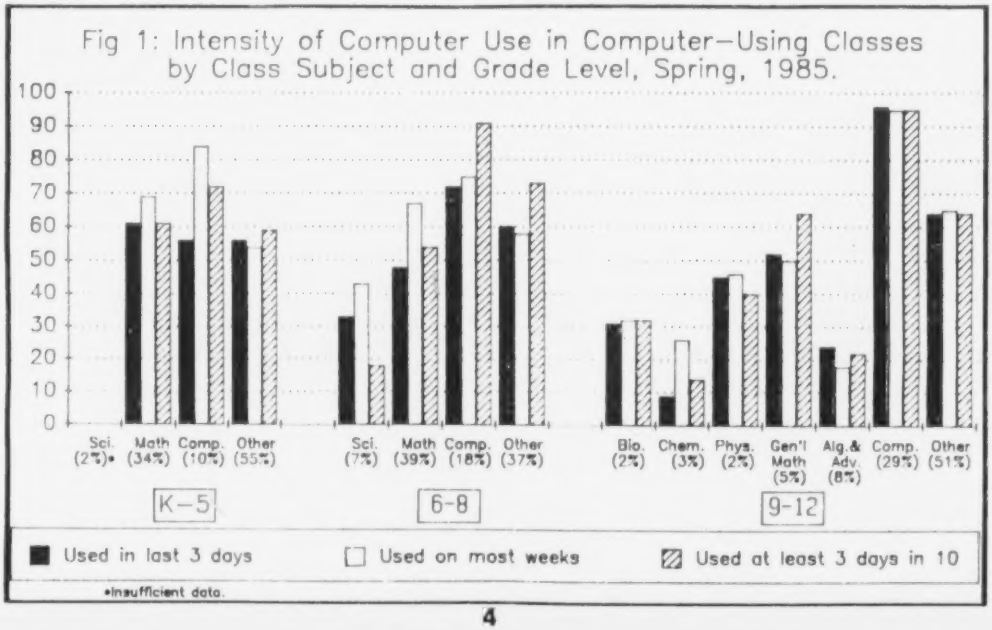


Table 2: Type of Computer Activities in Math, Science, and Computer Classes by Subject and Grade Level, Spring, 1985.

SUBJECTS BY GRADE LEVELS	TYPE OF ACTIVITY				
	Drills	Tutorials	Programming	Writing Text	Other Uses With 10 or More Percent
Elementary (K-5)					
Science class*					
Math class	72%	14%	8%	3%	
Computer class	11%	8%	24%	17%	28% (graphics, printing)
Other classes	69%	16%	4%	8%	
All K-5 computer using classes	62%	15%	8%	8%	
Middle (6-8)					
Science	25%	13%	22%	10%	27% (Simulations)
Math	58%	15%	15%	4%	
Computer class	14%	16%	54%	12%	
Other Subjects	47%	25%	6%	16%	
All 6-8 Subjects	40%	20%	23%	12%	
High School (9-12)					
Biology	85%	8%	0%	0%	
Chemistry	40%	31%	0%	1%	13% (Data applications) 14% (Simulations)
Physics	33%	16%	18%	2%	18% (Data applications)
All Science classes**	42%	13%	25%	3%	
Math: below algebra	68%	24%	0%	1%	
Math: algebra or more advanced	43%	14%	21%	0%	12% (graphing tool)
Computer class	7%	3%	75%	13%	
Other Subjects	31%	16%	9%	30%	
All 9-12 Subjects	22%	10%	40%	19%	

* Insufficient data.

** Includes earth science and general science also.

teaching programming skills. Programming can be used to improve mathematics or science comprehension as well. Particularly in classes like algebra, some of the programming activity focuses on programming objectives, some on mathematics objectives, and some on both. Nevertheless, between the programming occurring in explicitly organized computer literacy and computer programming classes and the programming within advanced mathematics and science courses, programming and not traditional math and science topics got the overwhelming emphasis among high school computer-using math and science teachers.

Table 2 also provides information about the dominance of drill-and-practice programs in basic and intermediate mathematics instruction using computers. More sophisticated tutorial (explanatory) and problem-solving programs and the more organizationally complex uses such as simulations, laboratory data collection, statistical graphing, and data retrieval programs were less frequent activities than were drills for mathematics at all grade levels. Math drills formed nearly three-fourths of the mathematics computer activity at the elementary grades and two-thirds of the remedial and general math use of computers in high school.

In contrast, science instruction using computers -- although limited in time -- was broader in scope. Simulation activities slightly outnumbered drill uses at the middle school level. In high school physics, drills occupied more time than any other single activity, but as a group, data-based applications, tutorials, programming, and use of word-processors comprised fully two-thirds of the computer activity for those courses. Chemistry courses involved substantial use of simulations, data bases, and tutorials. Among the high school science courses, drill activities were dominant only in biology -- where drills were about the only computer activity in use.

How Computers Were Used in Math and Science Instruction

Tables 3 through 6 provide a glimpse at how computer-using teachers used computers for mathematics and science instruction at different grade levels and with different types of classes. The information comes from survey questions about "the most recent occasion" on which the teacher used computers with a particular class.

Table 3: Characteristics of Most Recent Occasion of Computer Use, Elementary Mathematics Classes, For All Classes and Low Ability Classes, and by Teacher's Computer Expertise, Spring, 1985.

Characteristics of Most Recent Occasion of Use	All Classes	Low-Ability Classes	By Teacher Computer Expertise		
			Low	Medium	High
Percent of classes using computers					
in the classroom	77%	62%	81%	72%	81%
in a lab or elsewhere and teachers went to lab	15%	31%	15%	14%	13%
in a lab or elsewhere and teachers stayed in class	8%	7%	4%	14%	8%
Number of computers in room					
mean (median in parentheses)	3 (1)	4	3	3	4
Number of students present					
mean (median in parentheses)	20 (22)	11	19	20	19
Ratio of computers to students					
mean	1:15	1:5	1:15	1:15	1:13
median					
Percent of classes where ALL students in the class used computers that day	40%	32%	40%	38%	45%
Percent of classes in which ALL computer-using students did same assignment	48%	58%	55%	41%	35%
Percent where students did computer work					
Alone (with no help)	36%	51%	39%	19%	52%
Individually (with help or observation)	14%	16%	16%	14%	6%
In pairs	45%	29%	41%	54%	42%
In groups of more than two	6%	3%	4%	14%	0%
Mean number of minutes per student turn	17	22	16	18	20
Student activities on this occasion (adds to more than 100% -- multiple responses:					
Drills	84%	88%	84%	82%	92%
Tutorials	19%	10%	13%	21%	34%
Program writing	7%	2%	0%	15%	14%
Word processing	3%	2%	1%	4%	9%
Other	17%	16%	19%	13%	17%
While NOT using computers, students...					
watched computer users	6%	8%	5%	6%	3%
did individual seatwork	67%	74%	71%	68%	69%
small group work	19%	11%	16%	19%	18%
participated in class discussion	8%	7%	8%	6%	10%
Activity was considered to be...					
enrichment	55%	37%	59%	53%	53%
remediation	30%	57%	26%	37%	21%
regular instruction	15%	6%	16%	10%	27%
Teacher spent most of his/her time					
with students using computers	10%	17%	13%	9%	4%
with students NOT using computers	77%	56%	74%	73%	94%
(remainder said 'equal time with each')					
Some other items (not confined to the most recent occasion of use)					
What to do with students needing help?					
"Give them extra time on computer"	15%	24%	14%	10%	3%
What to do with rapid learners?					
"Give them enrichment on computer"	28%	24%	14%	40%	36%
Percent of classes using computers...					
more than 1 day per week	61%	47%	47%	76%	74%
more then 3 days per week	27%	21%	25%	21%	51%

Table 4: Characteristics of Most Recent Occasion of Computer Use, Middle Grade Mathematics Classes, For All Classes and Low Ability Classes, and by Teacher's Computer Expertise, Spring, 1985.

Characteristics of Most Recent Occasion of Use	All Classes	Low-Ability Classes	By Teacher Computer Expertise		
			Low	Medium	High
Percent of classes using computers					
in the classroom	45%	65%	62%	25%	32%
in a lab or elsewhere and teachers went to lab	47%	29%	24%	70%	64%
in a lab or elsewhere and teachers stayed in classroom	9%	7%	14%	5%	0%
Number of computers in use					
mean (median in parentheses)	5 (4)	4	3	5	9
Number of students present					
mean (median in parentheses)	18 (18)	13	20	16	20
Ratio of computers to students					
mean	1:10	1:7	1:13	1:6	1:8
median	1:4				
Percent of classes where ALL students in the class used computers that day	39%	39%	34%	47%	30%
Percent of classes in whcih ALL computer-using students did same assignment	45%	43%	43%	41%	53%
Percent where students did computer work..					
Alone (with no help)	44%	51%	52%	30%	50%
Individually (with help or observation)	8%	8%	7%	9%	0%
In pairs	40%	36%	35%	50%	38%
In groups of more than 2	8%	5%	6%	11%	13%
Mean number of minutes per student turn	19	20	18	18	24
Student activities on this occasion (adds to more than 100% -- multiple responses)					
Drills	73%	80%	65%	90%	54%
Tutorials	18%	27%	15%	16%	27%
Program writing	10%	3%	8%	8%	21%
Word processing	3%	0%	6%	3%	5%
Other	24%	19%	31%	11%	34%
While NOT using computers, students...					
watched computer users	9%	7%	5%	12%	5%
did individual seatwork	60%	58%	67%	52%	67%
small group work	11%	14%	4%	18%	19%
participated in class discussion	20%	61%	24%	19%	8%
Activity was considered to be...					
enrichment	39%	24%	55%	22%	32%
remediation	44%	57%	28%	69%	34%
regular instruction	17%	19%	17%	9%	35%
Teacher spent most of his/her time					
with students using computers	9%	11%	8%	13%	9%
with students NOT using computers	63%	60%	77%	46%	60%
(remainder said 'equal time with each')					
Some other items (not confined to the most recent occasion of use:					
What to do with students needing help?					
"Give them extra time on computer"	17%	12%	14%	21%	17%
What to do with rapid learners?					
"Give them enrichment on computer"	45%	50%	38%	62%	33%
Percent of classes using computers					
more than 1 day per week	53%	48%	46%	71%	27%
more then 3 days per week	20%	26%	24%	15%	16%

Each response is weighted according to the number of computer-using classes the teacher taught. This accounts for the fact that each teacher could report about only one class on the survey form. So the results picture how computers are used in computer-using math and science CLASSES at different grade levels.

1. Elementary mathematics classes

In three quarters of the elementary school classes in which computers were used for mathematics, students did their computer work in their own classroom rather than in a computer laboratory or other room. (See Table 3 for these and other results reported in this section.) In a majority of cases, only a single computer was available. The typical computer-to-student ratio was 1:13. In only 40% of the classes did all students in the class use computers on the same day, largely because so few computers were present in the room. For all students to have used computers for mathematics on the same day, it would have required computer activity to be spread over at least two hours during the day in most classes because a 1:13 ratio would not have enabled even half of the students to go to computers (in pairs) for, say, a 15 minute turn within the confines of a one-hour period for mathematics.

Computerized drill was by far the most common activity for elementary school mathematics. Programs that explained concepts or procedures (tutorials) were used only one-fifth as often as straight drills. In about half of the classes, the students doing math on the computers used different programs from one another. This was more likely because classes had only a limited number of copies of the same software than because of a planned program of individualized instruction. A majority of teachers regarded the computer work as enrichment (55%) rather than as remediation (30%) or as a regular part of mathematics instruction (15%). Teachers were twice as likely to suggest computer enrichment activities for students who finished their other work early as they were to suggest computer remediation activities for students who had trouble keeping up with the class (28% vs 15%).

Students worked in pairs almost as often as they worked individually (45% vs. 50%). In only one-third of the classes was computer use a totally solo activity -- individuals working without others helping or watching. The typical turn at the computer lasted 15 minutes. During the time that some students used computers, the remaining students were doing seatwork exercises in two-thirds of the classes. Whole-class activity was very infrequent during periods of computer use (8%). Teachers spent most of their time helping the students with their seatwork or other non-computer activities (77%) rather than watching over the students at the computers (10%).

Teachers were classified according to their computer expertise and experience (using self-report indicators of extent of computer experience, general educational level, extent of computer training, self-assessments of computer knowledge, reports of breadth of computer experiences, use of computers for professional functions, and extent of use of a computer at home). The teachers were classified into "low," "medium," and "high" groups according to arbitrary dividing points, with the "high" group encompassing 17% of the elementary computer-using math teachers and the "medium" classification applying to another 22%.

Among the teachers who used computers for math instruction in elementary schools, high-expertise and medium-expertise teachers used computers much more frequently than low-expertise teachers. They taught students of somewhat higher ability, but in many ways their pattern of use was similar to the way more typical "low-expertise" elementary math teachers used computers. They used drill-and-practice programs at least as frequently, but they also mixed in tutorials, programming, and word-processing more often than those computer-using elementary math teachers who were less "expert". As with the less expert teachers, only a minority of the more expert teachers were able to give ALL students in the class computer time on any one day. They gave students somewhat longer turns (20 minutes vs. 15 minutes). But seatwork dominated the time of students waiting for their chance to use computers as much as in other classes.

Computers were still seen primarily as an enrichment experience even by medium- and high-expertise teachers, but a higher proportion of the most expert teachers did report using computers as a regular part of math instruction (28%). Also, the teachers with the most

computer expertise individualized student computer assignments more than did others, and they had students work alone at computers more than other teachers did. Nearly all of the high-expertise teachers spent most of their own time with students who were NOT using the computers, having trained students to use the equipment without need of their own help.

Besides reporting data for all mathematics subject-matter instruction in classes for grades K to 5, Table 3 also provides data separately for classes for "low-" and "very-low" ability students. This group constituted 20% of all of the classes reported in the overall results. These lower-ability classes differed in their computer use from other elementary math classes in some ways. A higher proportion of their use went for remediation (57% vs. 30% for all elementary math classes). A higher proportion of their use was in computer labs as opposed to classrooms. They generally had a much better ratio of students-to-computers than in other math classes. Their teachers used a somewhat narrower range of software (i.e., a larger fraction of use was drill-and-practice rather than tutorials and programming activities). And they had less differentiated computer assignments (i.e., typically everyone used the same programs rather than different programs for different students).

2. Middle grade (6 to 8) mathematics classes

Compared to elementary math classes, math classes in grades six to eight that used computers used them much more often in computer laboratories and used them more for remediation and less for enrichment (Table 4). About as many middle grade math teachers (45%) saw computers as a way of keeping students occupied after they completed their other work as reported using computers for remediation (44%).

Middle grade math teachers used computers somewhat differently according to their own computer expertise. Medium- and high-expertise teachers overwhelmingly used computer in labs, but low-expertise teachers used them primarily in classrooms. And therefore, higher expertise teachers had more computers available and a better student-to-computer ratio. It is the medium-expertise teachers who used the computers most, however, not those with the highest computer expertise. And the medium-expertise teachers used computers more often for remediation and for providing activities to students who finished their other work than did other middle grade math teachers. They are also the ones who most often had students do their computer work cooperatively. The high-expertise math teachers at this level are distinguishable instead by their greater use of computers as a regular part of class instruction (rather than for enrichment or remediation) and by their greater diversity of software use (i.e., less reliance on drill-and-practice). But they were not as frequent computer users and two-thirds of them reported that non-users were engaged in seatwork, a higher fraction even than less computer-expert middle grade math teachers.

Among middle grade computer-using math classes, the 31% of classes involving lower-than-average ability students did not differ substantially from the remaining classes except for a somewhat greater emphasis on remediation. But the types of computer programs used, the way that students used computers, and what students did away from the computer in these low-ability classes were all roughly similar to how other middle grade math classes used computers.

3. High school mathematics classes

In high school mathematics instruction, computers were used very differently depending on the level of mathematics being taught (Table 5). General math classes used computers primarily for remedial purposes and emphasized drill-and-practice, and, to a lesser extent, tutorial programs. On the most recent occasion that computers were used in the class, students worked alone about half the time, just as in middle grade math classes, and, more often than not, different students used different software and some students didn't use computers at all. (Table 5 does not separate high school general math classes by teacher computer expertise because there were too few teachers in each category to present reliable data.)

In high school algebra and higher mathematics courses, activity patterns involving computers were quite different than those described for elementary, middle, and high school general math classes. Use of computers in higher math classes was much less frequent -- even if we restrict consideration to only those algebra and higher math classes that made some use of computers (as in Table 5). Only 13% of

Table 5: Characteristics of Most Recent Occasion of Computer Use, High School Mathematics Classes, For General Math Classes and Algebra/Higher Math Classes, the Latter by Teacher Expertise, Spring, 1985.

Characteristics of Most Recent Occasion of Use	General Math Classes	Algebra, Geometry, Trig, Advanced Math All Classes	By Teacher Computer Expertise Low	Med/High
Percent of classes using computers				
in the classroom	80%	59%	49%	69%
in a lab or elsewhere and teachers went to lab	17%	40%	47%	31%
in a lab or elsewhere and teachers stayed in classroom	4%	2%	4%	0%
Number of computers in use				
mean (median in parentheses)	8 (4)	8 (5)	9	7
Number of students present				
mean (median in parentheses)	17(20)	18 (20)	17	19
Ratio of computers to students				
mean	1:7	1:6	1:5	1:7
median	1:3	1:3		
Percent of classes where ALL students in the class used computers that day	32%	59%	53%	65%
Percent of classes in whcih ALL computer-using students did same assignment	44%	78%	76%	85%
Percent where students did computer work..				
Alone (with no help)	48%	19%	34%	8%
Individually (with help or observation)	18%	21%	11%	33%
In pairs	26%	45%	43%	36%
In groups of more than	8%	15%	12%	23%
Mean number of minutes per student turn	21	27	32	24
Student activities on this occasion (adds to more than 100% -- multiple responses)				
Drills	86%	42%	44%	37%
Tutorials	34%	23%	26%	26%
Program writing	0%	26%	29%	17%
Word processing	1%	4%	1%	8%
Other	13%	33%	19%	54%
While NOT using computers, students...				
watched computer users	4%	24%	18%	30%
did individual seatwork	84%	49%	40%	53%
small group work	2%	13%	26%	3%
participated in class discussion	10%	13%	16%	14%
Activity was considered to be...				
enrichment	29%	53%	60%	51%
remediation	57%	11%	19%	4%
regular instruction	14%	35%	22%	45%
Teacher spent most of his/her time				
with students using computers	23%	47%	28%	70%
with students NOT using computers	62%	31%	45%	25%
(remainder said 'equal time with each')				
Some other items (not confined to the most recent occasion of use:				
What to do with students needing help?				
"Give them extra time on computer"	11%	13%	15%	4%
What to do with rapid learners?				
"Give them enrichment on computer"	20%	21%	18%	27%
Percent of classes using computers				
more than 1 day per week	63%	13%	17%	9%
more then 3 days per week	37%	8%	15%	0%

Table 6: Characteristics of Most Recent Occasion of Computer Use, Middle and High School Science, Classes -- Middle Grade Classes by Teacher's Computer Expertise; High School Classes by Subject, Spring, 1985.

Characteristics of Most Recent Occasion of Use	Middle Grade Science Classes By Teacher Computer Expertise All	Low	Med/High	High School Science Classes Biology	Chemistry	Physics
Percent of classes using computers						
in the classroom	77%	73%	84%	86%	77%	58%
in a lab or elsewhere and teachers went to lab	17%	18%	13%	13%	12%	41%
in a lab or elsewhere and teachers stayed in classroom	6%	9%	3%	1%	11%	1%
Number of computers in use						
mean (median in parentheses)	4 (2)	4	4	3 (1)	4 (2)	4 (1)
Number of students present						
mean (median in parentheses)	23 (25)	23	24	22(20)	20(22)	15(18)
Ratio of computers to students						
mean	1:15	1:15	1:16	1:17	1:11	1:10
median	1:12			1:20	1:8	1:10
Percent of classes where ALL students in the class used computers that day	56%	41%	58%	27%	44%	50%
Percent of classes in whcih ALL computer-using students did same assignment	81%	88%	68%	97%	77%	96%
Percent where students did computer work..						
Alone (with no help)	21%	28%	20%	13%	4%	26%
Individually (with help or observation)	20%	32%	13%	31%	50%	13%
In pairs	29%	21%	23%	49%	40%	27%
In groups of more than	30%	19%	43%	7%	6%	35%
Mean number of minutes per student turn	20	17	21	21	24	23
Student activities on this occasion (adds to more than 100% -- multiple responses)						
Drills	54%	61%	50%	70%	50%	62%
Tutorials	19%	17%	23%	36%	26%	45%
Program writing	20%	21%	13%	1%	0%	15%
Word processing	6%	2%	10%	4%	1%	2%
Other	16%	8%	24%	23%	27%	43%
While NOT using computers, students...						
watched computer users	26%	*	*	*	14%	*
did individual seatwork	53%				36%	
small group work	6%				34%	
participated in class discussion	15%				16%	
Activity was considered to be...						
enrichment	72%	81%	72%	49%	38%	22%
remediation	4%	8%	1%	37%	27%	1%
regular instruction	24%	11%	27%	14%	35%	76%
Teacher spent most of his/her time						
with students using computers	22%	34%	14%	2%	3%	34%
with students NOT using computers	31%	42%	27%	57%	82%	25%
(remainder said 'equal time with each')						
Some other items (not confined to the most recent occasion of use:						
What to do with students needing help?						
"Give them extra time on computer"	19%	17%	21%	35%	9%	5%
What to do with rapid learners?						
"Give them enrichment on computer"	32%	17%	49%	11%	25%	17%
Percent of classes using computers						
more than 1 day per week	15%	7%	23%	*	14%	40%
more then 3 days per week	8%	3%	14%		10%	13%

* Under 30 teachers

the computer-using higher-level math classes reported using computers more than once per week compared to 63% of the computer-using high school general math classes and a majority of lower grade math classes.

But when algebra and other higher math classes did use computers, it was much more likely to be a major class activity. Compared to general math classes and to math classes at the lower grade levels, more often ALL students in a computer-using algebra class used computers during the same period (59% vs. 32% for high school general math classes); more often they did the same assignment on the computer (78% vs. 44%); the assignments were much more variable with drills being used on only 42% of the occasions (compared to 86% for general math classes); teachers were more personally involved with the computer activities rather than using that time to work with the rest of the class, and computer activities were primarily social interactions rather than solitary ones. In 60% of the higher math classes, students worked in pairs or groups even though the number of students per computer was generally better than in other math classes using computers. And in about one-half of the classes, students who were waiting their turn to use computers were observing the computer-users, doing small group activity, or participating in class discussions -- not doing seatwork, the waiting time activity that overwhelmingly dominated high school general math classes with computers (where 84% said this was the major waiting time activity). Interestingly, the higher level math classes did their computer work in labs much more often than did the general math classes, and yet clearly the computer activity, when it was used, was a much more integrated and important part of their course curriculum, a characteristic often associated in people's minds with classroom rather than laboratory location of use.

The most computer-knowledgeable higher math teachers (medium- and high-expertise teachers) were most oriented to having students use computers in cooperative ways. In only 8% of their classes did students work on computers by themselves. Those teachers spent more time with students who were using computers, as opposed to working with the students who were not using them. And they were much more likely to see computers as a regular part of the presentation of instructional material in their class, as opposed to enrichment or remediation activity. Interestingly, such medium- and high-expert teachers also used computers LESS intensively than did the others using computers for the same subject. Only 9% reported using computers more than once per week. Overall, the major differences between algebra/higher math classes and general math classes in their use of computers were even more pronounced among high school math teachers who were most knowledgeable about computers.

4. Middle grade science classes

Table 6 shows that science classes in the middle grades (and in the high school grades) overwhelmingly used computers in their own classroom rather than in a separate computer lab (77% vs. 23%). Typically, there were only 2 computers present, half as many as for middle grade computer-using math classes (where laboratory use was more common). The typical ratio of computers-to-students approximated that in elementary math classes (1:12). But computers were used very differently in middle grade science classes than in elementary math classes. In the first place, paired and grouped use was common. In 30% of the science classes at that level, students used computers in groups of three or more. Students worked alone without help in only one-fifth of the science classes (half as often as in general math classes). Students in the same class nearly always did the same assignment, very much like in the high school algebra/higher math classes. And seatwork was the major "off-line" activity in only one-half of the science classes -- again like the high school advanced math classes.

Middle grade science teachers split their time almost equally between observing students using computers and working with students who were not then using them (as opposed to the general math teachers who worked primarily away from computers and the higher math teachers who worked more with the computer users). But three-quarters of the computer-using middle grade science teachers saw computer use as being primarily an enrichment activity rather than a regular part of science instruction. Computers were used in 85% of these classes no more than one day per week. That, combined with the poor student-computer ratios, may have limited how well the teachers could integrate computer activities with their curriculum. The more computer-expert science teachers in the middle grades used computers more often with

their classes than those less expert about computers (the opposite pattern from the high school higher math teachers). Also, they emphasized students working at computers in groups more than any of the other teachers in the study. But they too saw computers primarily as enrichment aids rather than as a major means of developing knowledge of scientific facts or methods in their students.

5. High school science classes: biology, chemistry, physics

Like their middle school colleagues, high school science teachers used computers primarily in classrooms and therefore typically had few computers with which to work (Table 6). Overwhelmingly, they had all students do the same task on the computer, but typically not every student used computers on the same day. They used a broad range of computer activities, including a higher proportion of tutorial programs (compared to simple drill-and-practice) than math teachers or middle-grade teachers used.

These generalizations apply very similarly to biology, chemistry and physics classes, but in many other ways the three high school science subjects differed from one another substantially in how computers were used. Biology classes most resembled lower grade and math class use: 70% of the classes did drills on the most recent occasion that computers were used; in only 27% did all students use computers on that day; teachers much more often spent their time with the students who were away from the computers rather than with those using computers; enrichment was the primary function of computer use (only 14% said computers were a regular part of classroom instruction); and remediation was very important as well (35% said they'd give extra computer time to students who needed more help -- more than any other type of math or science teacher).

Students used computers cooperatively in high school science classes rather than individually, but paired use predominated in biology and chemistry classes while physics classes assigned computer tasks to groups of three or more students much more frequently and physics classes also had students work individually more often than in the other subjects.

Physics classes used computers more than did the others. Forty percent were reported to use computers more than once per week compared to 14% for chemistry classes. (These figures include only those science classes that used computers at least some times.) More significantly, in 76% of the physics classes computers were said to be a regular part of providing instruction rather than for enrichment or remediation, fully twice the proportion of high school algebra/higher math teachers giving this answer. Physics teachers spent at least as much time with students using computers as with students who were away from the computers.

Summary

Overall, computers clearly still play a small role in secondary school science instruction, except, perhaps, in high school physics. In 1985, relatively few computer-using science teachers reported using as many as 6 different computer programs with their students in any of their science classes (11% at the middle school level and 32% of the high school computer-users). Some science teachers were using simulations, lab interfacing programs, mathematics calculators, programs that compiled statistics or drew graphs, and other similar data-specific applications, and there was a relatively high degree of satisfaction with some of these categories of programs among those who used them. But very few computer-using science teachers were using these or any other type of instructional software very intensively. As of 1985, there is only the hint that secondary school science instruction might be profoundly affected by computers. The impact is largely still in the future.

In mathematics, computers in 1985 were playing both more and less of a role than they were in science. As a medium through which students at all grade levels can practice basic skills in arithmetic, computers were being widely used from the lowest to the highest grade levels. However the impact on any individual student is difficult to see because very few students using computers in these ways were getting a substantial amount of computer time (e.g., 30 hours during the school year). For higher levels of school mathematics, from algebra on up, the evidence suggests that the

involvement of computers in traditional instructional topics was yet very small.

Apart from basic arithmetic computation, computers have had a major impact on pre-college mathematics in two ways: as a stimulus for providing a new emphasis on logic, problem-solving, and applications of mathematics; and as an object of instruction itself -- the focus on computer literacy and computer programming. These changes in the content of mathematics education can be observed at all levels from elementary to high school. In the elementary grades, the changes show up as activities for keyboard familiarization, in the use of instructional computer programs as "exemplars" of computer-based intellectual activity, in rudimentary programming instruction in both "Logo" and "BASIC," and in occasional use of word-processing programs. In high school, the evidence is strong that semester-long courses in computer programming, and sometimes a whole computer science curriculum, has taken its place as a regular feature of the high school academic curriculum. At the middle grades, a wide range of activities that make use of computers from relatively simple programming to the use of logic and strategy games has been offered to an even broader clientele than the high school computer programming courses. The next newsletter issue will provide detailed data about how computers are being used in these areas.

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